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l. 3. No. 2 Pittsburgh, Pa. February, 1930

IN THIS ISSUE

Calorimetry in America
PROF. S. W. PARR

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Recording Gas Calorimeters
Bomb Calorimeters
B. T. U. Indicators
Steam Calorimeters

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Measurements—Industrial & Scientific
DR. WALTER BLOCK

◆

Temperature, That Peculiar Thing
M. F. BÉHAR

◆

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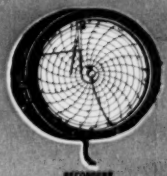

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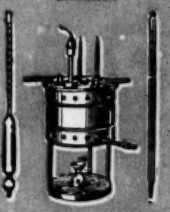
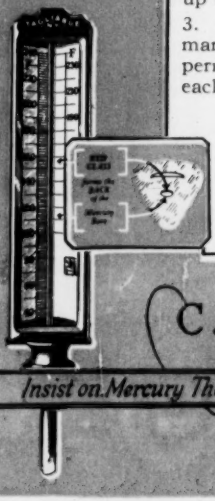


OIL TESTING INSTRUMENTS, THERMOMETERS, HYDROMETERS, ETC



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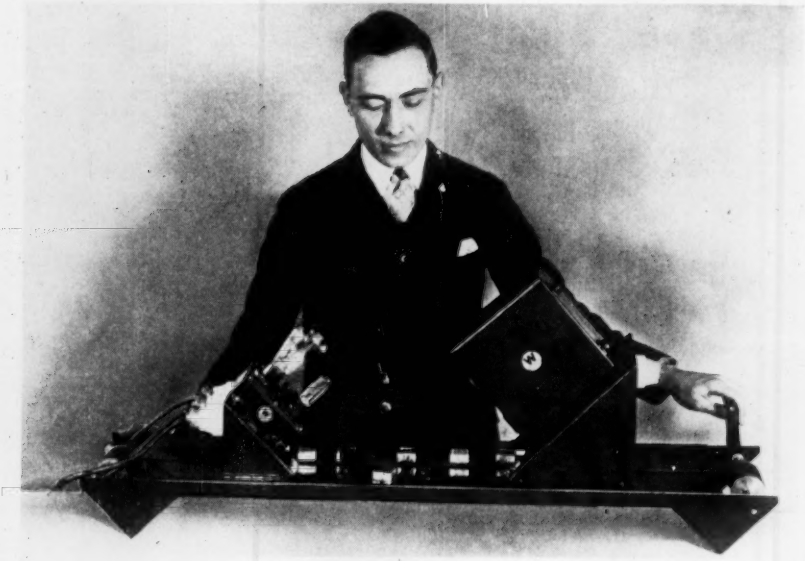

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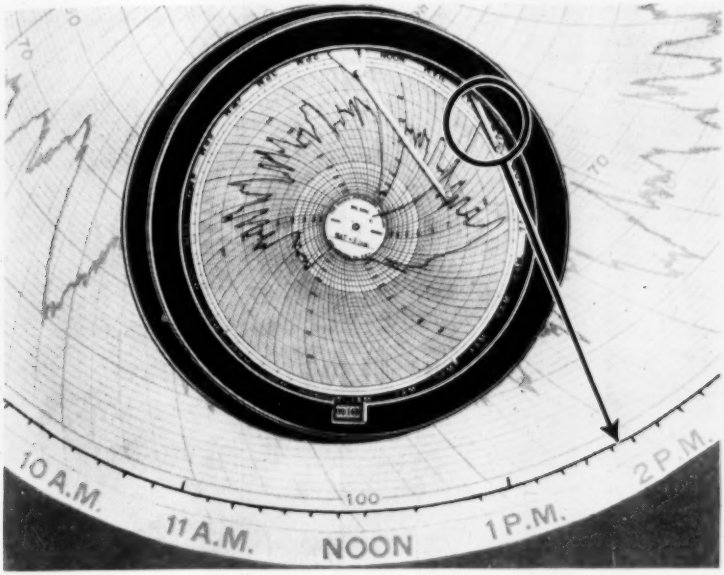

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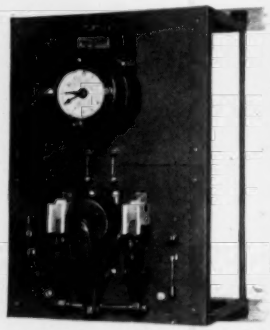

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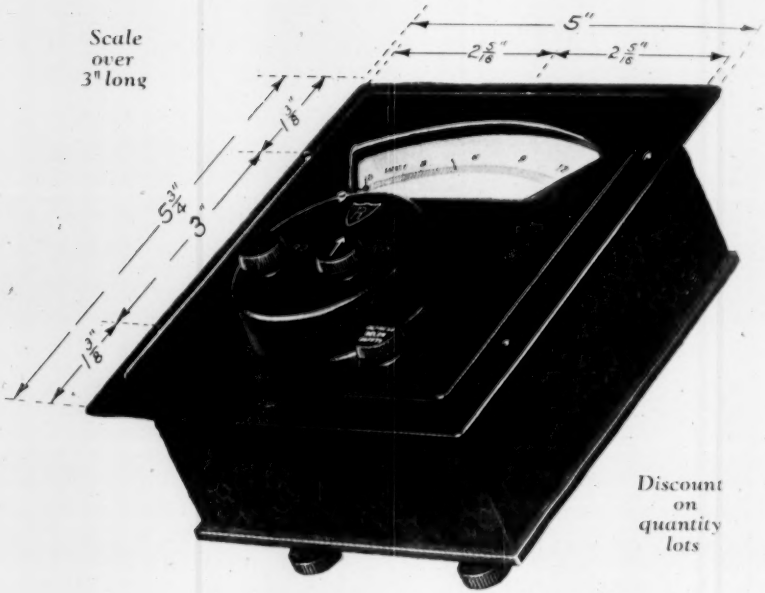

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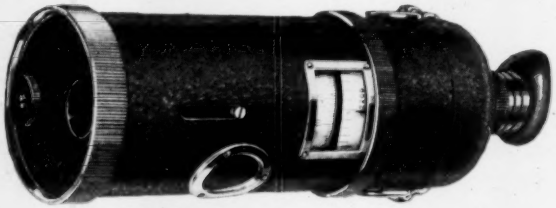

can be used

—for checking temperatures in the coke and gas industries. Temperatures read through the flue covers and the buckstrap openings permit the operator to keep his ovens at the right temperature, to locate hot spots in the brickwork, etc.

—in the iron and steel industry for checking the operating temperatures of open hearth furnaces, soaking pits, heating furnaces, crucible furnaces, rolling and forging, cupolas and puddling furnaces.

—in glass, ceramic and brick plants for temperatures of melting furnaces, kilns, enameling furnaces, enamel smelters, glazing kilns, etc.

—in the cement industry for checking the sintering zone, etc.

—for the measurement of temperatures in boiler furnaces, heat treating furnaces, incinerators, etc.

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—it can be checked at any time, a standard lamp is included in each pyrometer. The lamp can be replaced by the operator without changing the accuracy.
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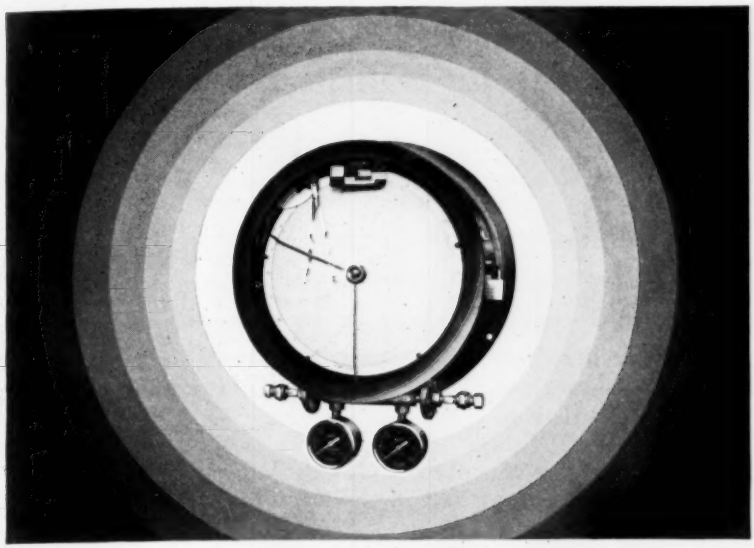

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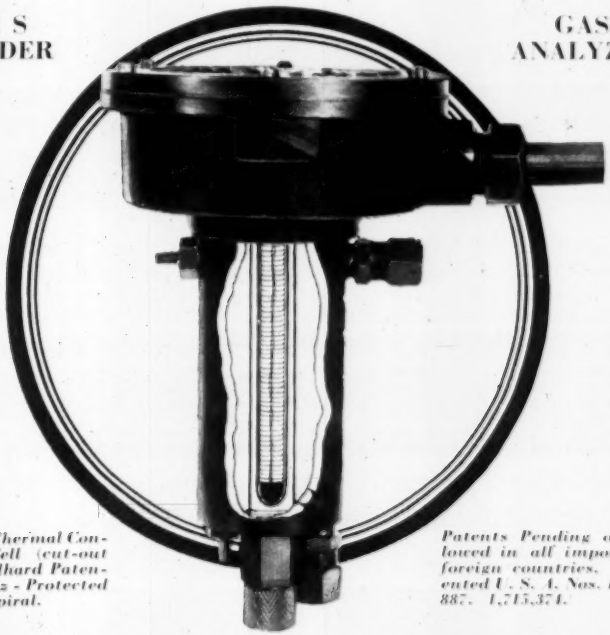
TYPE S RECORDER

GAS ANALYZER



Engelhard Thermal Conductivity Cell (cut-out shows Engelhard Patented Quartz - Protected Platinum Spiral.

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The Engelhard quartz-protected Thermal Conductivity Cell *prevents inaccurate analyzation*

The United States Bureau of Standards advocates thermal conductivity for most efficient gas analyzation. Ordinary cells in general use, however, have a calibration drift which requires considerable corrective checking and readjustment. Simple though such adjustment is, the *need* for it detracts from the reliability of records.

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This type of cell maintains its accuracy indefinitely. It is the highest development in gas analyzing efficiency now available.

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Recording and indicating instruments, automatic temperature and gas control, pyrometers, gas analyzers, thermometers.

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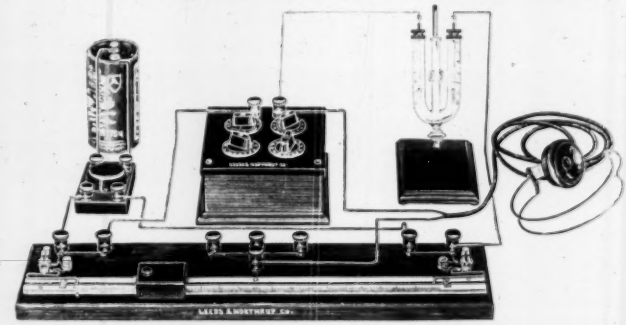

The above group of instruments is suitable for students' measurements of electrolytic conductivity with the Kohlrausch modification of the Wheatstone Bridge. This arrangement features our Students' Slide Wire with exposed circuits. It is unmistakably clear and simple, and is much used for elementary instruction. The resistance is high enough to produce a fairly symmetrical bridge.

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4775	4-DIAL RESISTANCE BOX, 9 (+ 10 + 100 + 1000) ohms	40.00
5412	BUZZER	10.00
4912	STUDENTS' U CELL, not including stand and clamp	26.00
9872	TELEPHONE RECEIVER	5.50
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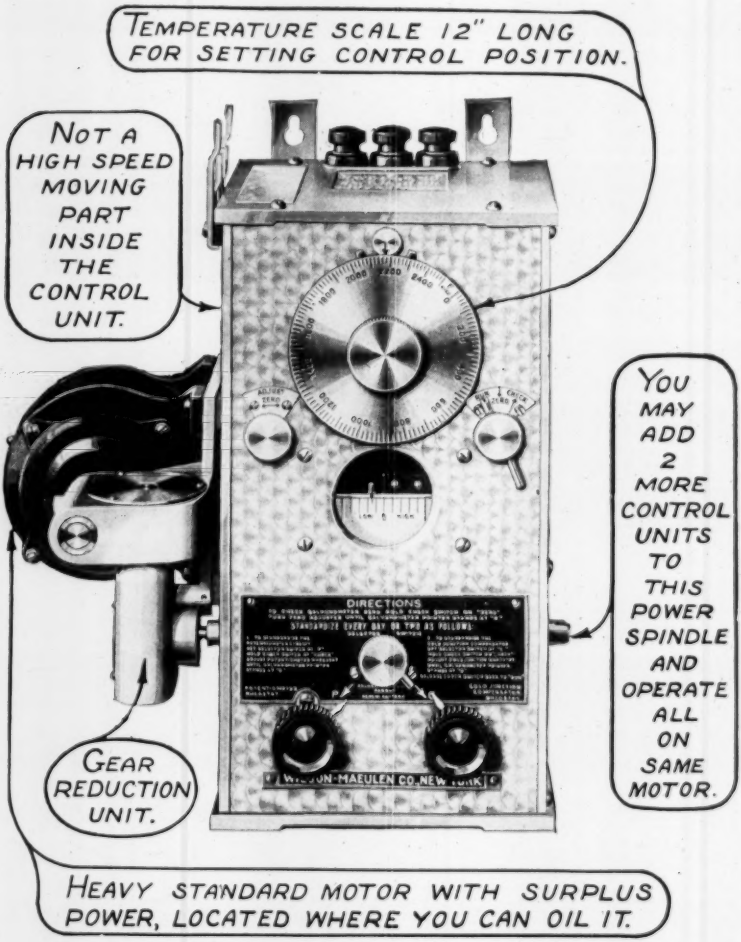
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NOT A HIGH SPEED MOVING PART INSIDE THE CONTROL UNIT.
YOU MAY ADD 2 MORE CONTROL UNITS TO THIS POWER SPINDLE AND OPERATE ALL ON SAME MOTOR.
GEAR REDUCTION UNIT.
HEAVY STANDARD MOTOR WITH SURPLUS POWER, LOCATED WHERE YOU CAN OIL IT.
DIRECTIONS

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WILSON-MAEULEN CO
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387 Concord Ave. New York, N. Y.

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

(Reg. U. S. Pat. Off.)

Vol. 3, No. 2 FEBRUARY, 1930 Pittsburgh, Pa.

To Our Readers

THIS issue is a result of the interest expressed from time to time in calorimetric measurements. The editor endeavored to include in this issue the descriptions of all devices called calorimeters, as there is no single place in the literature to-day where an attempt has been made to bring together information on this subject.

Below are listed books on calorimetry, for those who desire to read further on this subject:

American Gas Institute—Committee Reports on Calorimetry; and Erecting and Operating Gas Calorimeters.

J. H. Coste—Calorific Power of Gas, 1911.

J. H. Coste & E. R. Andrews—Fuel: Gaseous, Liquid & Fuel, 1914.

J. D. Davis & E. L. Wallace—Technical Paper 91, U. S. Bureau of Mines, A Convenient Multiple—Unit Calorimeter Installation, 1917.

H. C. Dickinson & N. S. Osborne—Scientific Paper 247, U. S. Bureau of Standards, An Aneroid Calorimeter, 1915.

H. C. Dickinson—Scientific Paper 230, U. S. Bureau of Standards, Combustion Calorimetry and the Heats of Combustion of Cane Sugar, Benzoic Acid and Naphthalene, 1914.

H. C. Dickinson & E. F. Mueller—Scientific Paper 68, U. S. Bureau of Standards, Calorimetric Resistance Thermometers and the Transition Temperature of Sodium Sulphate.

H. C. Dickinson & E. F. Mueller—Scientific Paper 200, U. S. Bureau of Standards, New Calorimetric Resistance Thermometers, 1913.

H. C. Dickinson & N. S. Osborne—Scientific Publication 248, U. S. Bureau of Standards Specific Heat and Heat of Fusion of Ice. 1915.

H. C. Dickinson, D. R. Harper 3rd & N. S. Osborne—Scientific Publication 209, U. S. Bureau of Standards, Latent Heat of Fusion of Ice.

A. Gill—Gas & Fuel Analysis for Engineers, 1925.

D. R. Harper, 3rd—Scientific Paper 231, U. S. Bureau of Standards, Specific Heat of Copper in the Interval 0° to 50°C, with a Note on Vacuum—Jacketed Calorimeters, 1914.

N. S. Osborne & M. S. Van Dusen—Scientific Publication 313, U. S. Bureau of Standards, The Specific Heat of Ammonia, 1917.

N. S. Osborne & M. S. Van Dusen—Scientific Publication 314, U. S. Bureau of Standards The Latent Heat of Pressure Variation of Liquid Ammonia, 1917.

N. S. Osborne & M. S. Van Dusen—Scientific Publication 315, U. S. Bureau of Standards The Latent Heat of Vaporization of Ammonia, 1917.

N. S. Osborne—Scientific Paper 301, U. S. Bureau of Standards, Aneroid Calorimeter for Specific and Latent Heats, 1917.

H. Poole, rewritten by R. T. Kent—Calorific Power of Fuels, 1918.

U. S. Bureau of Standards—Circular 48 Standard Methods of Gas Testing, 1916.

U. S. Bureau of Standards—Circular 11, Standardization of Bomb Calorimeters.

U. S. Bureau of Standards—Circular 65, Gas Calorimeter Tables.

C. W. Waidner & E. E. Mueller—Technical Paper 36, U. S. Bureau of Standards Industrial Gas Calorimetry, 1914.
Alfred H. White—Technical Gas & Fuel Analysis, 1920.
Walter P. White—The Modern Calorimeter, 1928.

"Employ your time in improving by other men's documents, so you shall come easily by what others have labored hard for."—*Socrates.*

The International Temperature Scale

ALTHOUGH INSTRUMENTS is a young magazine entering its third year, it was within its life that a magnificient achievement, of importance to all thermometer users in the civilized world, was announced, when in the October 1928 Bureau of Standards Journal of Research, THE INTERNATIONAL TEMPERATURE SCALE was published. It is fitting that a résumé of this international agreement—the fruit of years of labor—should appear in this issue of INSTRUMENTS devoted to Calorimetry. Such a résumé is given in our Engineering Editor's article "That Peculiar Thing, Temperature," and is preceded by an entertaining yet informative discussion of what the author calls "one of the few purely intensive and dimensionless measurable magnitudes of physical phenomena."

Are We Going Instrument Wise?

THE editor takes this opportunity to welcome the latest addition to the field of periodicals, wholly confined to instruments—THE REVIEW OF SCIENTIFIC INSTRUMENTS.

That there is a need for this publication in spite the large number of existing periodicals, is ably pointed out in the editorial appearing in Volume 1, Number 1:

"The number of scientific and technical periodicals to which any worker in either pure or applied science must refer has increased so rapidly in recent years as to raise in some minds the question of the desirability of taking steps to discourage the starting of new journals. While it is probably the consensus of opinion of those who have given the matter thought, that new journals should not be started except in response to a pressing demand, yet it is certainly true that the rapid increase in the total volume of scientific work during the past quarter century makes imperative a corresponding increase in facilities for publishing results of investigations. Either existing journals must be enlarged or new ones must be started. Only by preventing a further increase in scientific work, can one prevent a continued increase in the total volume of scientific literature. Partly because there is a practical limit to the size of any given journal, partly because the development of new fields makes new journals desirable for the better classification of literature, a continued increase in the number of such journals seems inevitable.

When the Optical Society of America was approached several years ago with the proposal that it add to its journal, the then Journal of the Optical Society of America, a section devoted to scientific instruments, it was urged that such a procedure would make it possible to ascertain, without actually establishing a new periodical, whether there is need in America for an instrument journal and that after a reasonable trial period, either a separate instrument journal could be established or the section dropped, as experience dictated. Accordingly, in 1922, such a section was added to the Journal and its name changed to "THE JOURNAL OF THE OPTICAL SOCIETY OF AMERICA AND REVIEW OF SCIENTIFIC INSTRUMENTS." This addition, made at the suggestion of the National Research Council, was made possible by the cooperation of the Scientific Apparatus Makers of America.

This section on scientific instruments seems to have served a very useful purpose during the past eight years. It has carried a great variety of articles on instruments of all kinds, and has, we believe, made a permanent place for itself among the scientific periodicals of America. The time has apparently come to take the next logical step: that is, to establish a separate journal. Hence, The Optical Society of America, with the continued cooperation of the Scientific Apparatus Makers of America, presents herewith Volume I (New Series), Number I, of THE REVIEW OF SCIENTIFIC INSTRUMENTS."

We welcome this new publication most heartily.

The Censuses of Manufactures and Distribution.

THE coming census of the United States will be the most comprehensive statistical compilation ever undertaken in this or any other country. It will cover population, occupations, agriculture, irrigation, drainage, manufactures, mines, quarries, unemployment, and distribution.

This is the first time we are to have a census of distribution, which may be defined briefly as a gathering of statistics in regard to wholesale and retail trade. It will show the number of persons employed by merchandising establishments; the principal expenses of such concerns, including rent, interest, and wages paid; the stock of goods on hand December 31, 1929; and the sales of broken down commodity groups, so far as practicable, all classified geographically by kind of distributor, size of establishment, and in other significant combinations. The inclusion of this subject of distribution means a very material addition to the work of taking the next census. It is estimated that it will be necessary to canvass nearly two million establishments.

The need for the kind of information which may be obtained through a distribution census is very generally realized, and has been urged upon the Government by manufacturers, merchants, chambers of commerce, representatives of business organizations, and others. It is generally asserted that one of the reasons why we have not made improvements in the efficiency of distribution corresponding to those that have been made in production is that we have hitherto possessed relatively little comprehensive information about the movement of commodities.

The Government will be greatly assisted in preparing its report on the distributive system of the country if the merchants cooperate by supplying the requisite data promptly and accurately.

Each manufacturer is also urged to see to it that the questionnaire of the censuses of manufactures which he has or will presently receive from the government is filled out accurately and completely and is mailed at once in the return envelope that came with it.

After acceptable returns have been received from all the members of an industry a preliminary report for that industry will be prepared and published. This report will be sent out to all who ask for it.

As the preparation of these preliminary reports requires usually only a day or two after the receipt of the last return, and as multigraphing and mailing consume only about two weeks (allowing a week between date of mailing and reclose date), it is obvious that the date upon which this report will be available depends upon the promptness and accuracy with which the members of the industry send in their reports.

All manufacturers may be assured that their report will be treated by the government in absolute confidence and will not be disclosed to any person who is not a sworn employee of the Census Bureau, not even to an official employee of some other government department or of the Department of Commerce outside the Bureau of the Census—as stated clearly on the questionnaire.

Cooperate with the Bureau of the Census.

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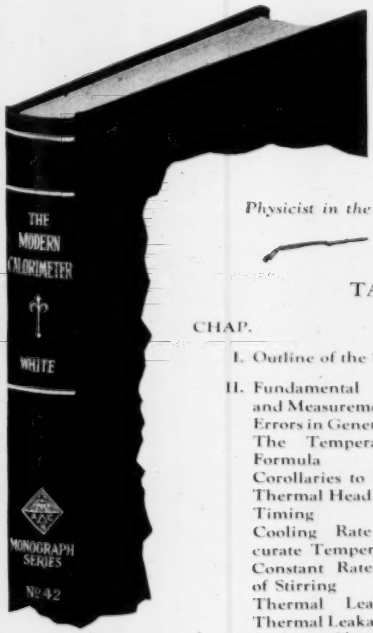

THE MODERN CALORIMETER

by

Walter P. White, Ph. D.

Physicist in the Geophysical Laboratory of the Carnegie Institute of Washington.

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Calorimetry in America.

*Prof. S. W. Parr**

CALORIMETRY came very near being born in America. If one were to burnish up some of the odd corners connected with the revolutionary period of American History, there is one of more than passing interest in connection with the development of the field of Technical Science. It would run somewhat as follows:

On the 26th of March, 1753, at North Woburn, near Boston, was born Benjamin Thompson. In 1772, at the age of nineteen, he was commissioned by Governor Wentworth a Major in the Second Provincial Regiment of New Hampshire. The enmities and accusations that followed this appointment, growing into a serious threat against his life in 1774, caused him to embark for England in October, 1775. In England his investigational opportunities were greatly extended. Some of his experiments, especially in connection with gunpowder, were communicated to the President of the Royal Society. As a result of this and other scientific accomplishments, he was made a Fellow of that Society in 1779. In 1784 he was appointed by the Elector of Bavaria to a combined military and civil position at Munich, where he established notable reforms growing directly out of his scientific studies relating to the properties of heat and their correct application in the preparation of food. In this same year he was knighted by the King of England, George III, and chose for his title that of Count Rumford, honoring in this way the town of Rumford, later Concord, New Hampshire where he spent the most active years of his life in America.

It will take us too far afield to follow the subsequent career of Count Rumford. Any one desirous of details will find most entertaining accounts of his life, by Professor Tyndall, delivered as lecturer in 1883, "On Count Rumford, Originator of the Royal Institution." Aside from his remarkable accomplishments in the adaption of scientific facts to problems of everyday living, his most notable achievements along scientific lines were as follows:

He was the originator of the formal generalization known as the Mechanical Theory of Heat, based on experiments conducted on a scale unexampled at the time, whereby he was able to prove that heat was a form of motion. He was elected to the "Institute of France," in 1803, and lectured before its classes on subjects engaging his attention while a resident of France. He lived near Paris from 1808 till 1814, and,—

> "On February 24th, 1812, he brought before his class in the Institute some further inquiries concerning heat with a description of his calorimeter."

Curvier, the permanent Secretary of the Institute, in his eulogy at the time of Count Rumford's death, in 1814, refers to his career in Bavaria, with its noble services and its high honors,—does justice to his genius in Science, and traces his devoted and eminently successful labors for ends of public utility and benevolence, especial reference being made to his scientific occupations after he had taken up his residence in France; quoting directly from Cuvier's *Eloge*;—Life of Count Rumford by G. E. Ellis, page 617:—

> "He has constructed two singularly ingenious instruments of his own contrivance. One is a new calorimeter for measuring the amount of heat produced by the combustion of any substance. It is a receptacle containing a given quantity of water, through which passes, by a serpentine tube, the product of the combustion, and the heat that is generated is transmitted through the water, which, being raised by a fixed number of degrees, serves as the basis of the calculations. The manner in which the exterior heat is prevented from affecting the experiment is very simple and very ingenious: he begins the operation at a certain number of degrees below this outside heat, and terminates it at the same number of degrees above it. The external air takes back during the second half of the experiment exactly what it gave up during the first."

*University of Illinois.

Rumford founded certain Prizes and Bequests, a Prize to be awarded not oftener than once in two years by the Royal Society of London, to persons achieving notable results in the study of heat and light, "the preference always being given to such discoveries as shall in the opinion of the President and Council tend most to promote the good of mankind."

A duplicate award, with precisely the same wording, was made to the Academy of Arts and Sciences of America, under date of July, 12, 1796. This award was greatly appreciated by the Academy.

> "The members of the Academy regarded it as the most helpful and encouraging recognition which their institution had received during the sixteen years of its existence."

Count Rumford had been elected an Honorary Member of the American Academy in 1789.

Count Rumford bequeathed the residue of his estate to Harvard College for the purpose of founding a Professorship, the holder of which should:

> "teach by regular courses of academical and public lectures, accompanied with proper experiments, the utility of the physical and mathematical sciences for the improvement of the useful arts, and for the extension of the industry, prosperity, happiness and well-being of society."

Jacob Bigelow was appointed to the first Rumford Professorship. His inaugural address was on the life and works of Count Rumford; in the concluding paragraph he says:

> "To the country of his birth, Count Rumford has bequeathed his fortune and his fame . . . . Let those who would depreciate our native genius, remember that he was an American."

Dr. Bigelow's lectures, delivered in connection with the Rumford Professorship, were published in 1829, under the title, "Elements of Technology" thus introducing the use of a word among us which now serves to express an entire system of education by new methods to new uses.[1] Fifty years after his inaugural at Harvard, Dr. Bigelow delivered the opening address at the inauguration of the Massachusetts Institute of Technology, November 16, 1865, thus initiating a movement in the educational field, the significance of which at the time, or the importance of which even now can scarcely be realized. We may therefore credit Count Rumford directly with the establishment in this country of Technological Education.

This brief historical circuit brings us around, with ample justification, to our initial statement that "Calorimetry came very near being born in America."

Other attempts had been made to measure heat quantitatively but they were crude in type and incorrect in principle from our present-day knowledge. It is to be noted particularly therefore that Count Rumford developed a calorimeter which for the first time embodied the principles which are now recognized as fundamental in such an apparatus. He burned a known weight of fuel in such a manner as to transfer the heat produced to a known weight of water, thus establishing the two units of reference which made it possible to express the heat value of a combustible substance in units of standard and known terms. He calculated his values to the number of kilos of water that a unit kilo of fuel would raise through one degree.

This was for many years the method of expressing calorimetric values. The present method now more uniformly used gives the same value but is expressed in the degrees rise of temperature which one kilo of fuel will impart to one kilo of water.

Nevertheless, the apparatus of Count Rumford was not without its critics. In 1826 Mr. Marcus Bull of Philadelphia, read a paper before the

[1] Ellis—Life of Count Rumford, page 638.

Philosophical Society of Philadelphia, finding fault with Rumford's method, claiming that what was desired in a fuel calorimeter was some system which would give directly the relative values of different fuels used in the arts or for domestic purposes. He devised a calorimeter of his own which furnished such values. His paper, with illustrations and results, was read before the Philadelphia Academy of Science April 7, 1826. It consisted of a detached and insulated room 8 x 8 x 8 feet, in which an attendent kept up a fire in a small heater in such a manner as to maintain a given temperature for a definite length of time, and the weight of the various fuels thus tested furnished a series of ratios when referred to a given fuel selected as a standard of reference. Mr. Bull's method would seem to be rather crude, but it is of decided importance to note that this method of developing ratios has possiblities of extreme exactness, being limited, of course, by the degree of uniformity as to the conditions under which the several tests could be conducted.

The next outstanding investigation in America was made by Professor W. O. Atwater, at Wesleyan University, Middletown, Conn., 1895 and 1899, who may have taken some remote hint from Bull's experiments, though there is nothing in the literature to suggest that idea. At any rate, he developed his respiratory or human calorimeter along somewhat similar lines, building a room so well insulated that the heat in-put in the way of food could be definitely measured in heat units, as put out by the human system. While this life-sized calorimeter was a great accomplishment in itself, it can readily be seen that its use and value would depend directly upon the theoretical or exactly determined heat value of the food supplied to the subject within the large apparatus.

This led Professor Atwater to devise a calorimeter along the lines proposed at about the same time by Mahler, and somewhat earlier by Berthelot of France. Professor Atwater's instrument consisted of a steel bomb lined with platinum, and capable of retaining oxygen under high pressure of 25 to 50 atmospheres, with provision for igniting the food sample by electric contact through the cover of the bomb. The bomb was submerged in a known weight of water, held by a round can or vessel of pewter.

It will be seen that we have here a departure from the method used by Rumford, whose experiments were conducted at constant pressure, whereas, with Atwater, we have a system wherein the combustion is carried on at constant volume.

It is not our purpose to follow the developments in detail along these two lines. Rumford's followers were Dulong, in 1838, who substituted oxygen for air. Favre and Silberman, in 1852, introduced numerous mechanical improvements, and Fischer went still further by constructing his combustion chamber of silver.

All of these devices encountered serious difficulties when used with coals of high ash content, on account of incrustation, which prevented complete combustion of the charge. The constant volume type came chiefly as a relief from the difficulty of incomplete combustion, and has been further promoted in popularity by the ease with which oxygen in high compression cylinders could be obtained. The development of high compression or constant volume calorimeters was brought about by Berthelot in 1881, who used a platinum lining for his bomb. Also, as already noted, by Atwater, who also used a platinum lining, and by Mahler, in 1892, who proposed a cheaper construction by using a bomb having an enameled lining.

Another radical departure in the method of determining the calorific value of fuels was devised by Parr, in 1899, and described in a bulletin of the University of Illinois for that year, and also in the Journal of the American Chemical Society.[2] The method thus proposed made use of the oxidizing power of sodium peroxide. The products of combustion, being CO_2 and H_2O, were at once incorporated as solid constituents by the chemical employed, so that no pressure of escaping gases had to be taken care of. The heat of the reaction was sufficient to convert the entire charge into a fused mass, thereby making it possible to use a cylinder of relatively small proportions and of such compact form that it could be made to revolve upon its own axis, thus furnishing the mechanical means for stirring the surrounding water throughout the period of the test. The reactions involved have been found to be exceedingly constant in behavior, and have been shown to serve as an excellent medium for measuring the calorific value more especially of hydrocarbon fuels, such as coal of all types, and oil.

Moreover, sodium peroxide fusions now cover a wide range. They have been extended to include the determination of carbonaceous matter as humus in soil, sulphur in coal, coke and foods, as well as for the determination of halogens in organic compounds, to replace the time-honored Carius method. Some idea as to the extent of such application may be formed from the fact that approximately one ton of specially prepared sodium peroxide is used for this work annually.

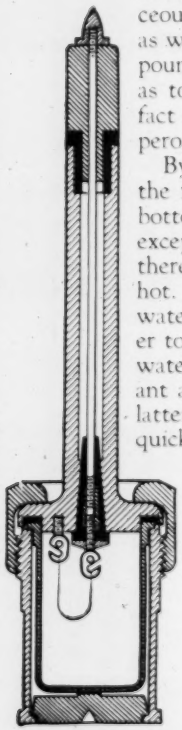

Fig. 1

By reference to Fig. 1, there is shown a jacketing support for the fusion cup, while in the space surrounding the sides and bottom of the fusion cup is entrapped air which cannot escape except upon ignition of the charge. During the fusion period, therefore, the walls and bottom of the fusion cup become red hot. Cooling begins after about two minutes, at which time water is drawn in through vents near the lower edge of the holder to replace the air driven out by the heat. This accession of water into the air space during the cooling period is as important as the retention of air during the combustion period. The latter insures completeness of combustion and the former insures quick and complete transmission of the heat to the surrounding water.

For reasons not at first readily understood, the use of an accelerator is necessary in order to obtain complete and consistent reactions. The accelerator used for a long time was potassium chlorate, $KClO_3$, but since the perchlorate salt, $KClO_4$, has come to be readily available, it has displaced the earlier chlorate as an accelerator. The chief reasons for the change can be readily understood. For example, the ordinary chlorate in decomposing from $KClO_3$ to $KCl + O_3$ is exothermic and its heat of decomposition must be included as part of the correction factor to be applied. It is advantageous to eliminate that correction not only on the score of simplification but in the presence of the organic matter of the charge, this decomposition of $KClO_3$ has a tendency to be unduly rapid or boisterous, and especially so if, by chance the operator

[2] Journal of the American Chemical Society, Vol. 22, 1900, pages 646-652.

should forget to add the 15 grams of sodium peroxide called for in making up the charge. Under such conditions the mixture has the property of gunpowder in the speed of its reaction. On the contrary, a mixture of perchlorate and coal alone does not constitute an explosive mixture.

The function of an accelerator may be explained as follows,—The heat of the reaction brings the charge to a liquid state and neither at that stage or immediately following where it becomes solid, could an atmosphere of free oxygen, as used in the Atwater method, contribute greatly to the completeness of the reactions. On the other hand, if the accelerator is brought to a high degree of fineness and evenly distributed throughout the mixture, the oxygen liberated by the accelerator is not only at the exact spot where it is needed, but is also at the moment in the nascent state. Under these conditions there is secured not only a complete oxidation of the organic matter but any reactions which would otherwise rob the Na_2O_2 of an atom of oxygen, have at hand compensating conditions which bring the Na_2O back to its normal and more stable condition of Na_2O_2.

It is not in place here to go into the details of operation or to discuss the corrections and factors to be applied. These features are fully set forth in the book of directions which accompanies each instrument. In general, the behavior of the instrument may be summarized as follows:

The reactions which occur in the case of hydrocarbon compounds are exceedingly exact and constant and admit of a high degree of accuracy as to results, and when compared with those obtained by the oxygen bomb method, should be well within the limit of toleration set by the A. S. T. M. and the A. C. S. However, decided emphasis should be placed on giving the sodium peroxide fusion method an equal chance with the oxygen bomb procedure. The shortcoming most commonly practiced is in the use of an inferior thermometer.

The thermometer to be used with the sodium peroxide method should be, in every respect, the equal in accuracy to that used in the oxygen bomb instrument. If a high grade Beckman is used in the oxygen bomb instrument, the sodium peroxide instrument is entitled to the same consideration, and certainly in a test case of comparison determinations the same thermometers or exact equivalents should be employed. The peroxide instrument is worthy of this consideration, and too strong a plea cannot be entered on this score. The most astonishing crudities are occasionally met with in the way of thermometers. A calorimeter is no better than the thermometer that is used with it. In general, a good mercury thermometer is better than a resistance couple, and a solid stem properly made and calibrated is better than a Beckman. However, a certificate may be worth little, if made on a thermometer of unseasoned glass, and it may be added, is entirely worthless unless the corrections are observed. Let it be noted also that thermometric accuracy as to actual temperature is not essential but the differential error over any range likely to occur in use should not exceed 0.03°F. By plotting the certificate variations in the form of a curve, it is a simple matter to correct for the error involved in any reading, and this refinement should be consistently observed.

One further advance in calorimetric apparatus has been made as a result of investigational activity in America. This seeks to avoid the expense of a platinum lining, and also the objectionable features of an enameled sur-

face, with its liability to cracking and consequent exposure of the metal to corrosion from the mixed sulphuric and nitric acids which accompany the combustion, especially of high sulphur coals. Following the Berthelo ttype of bomb, as improved in pattern by Atwater, and eliminating the use of a platinum lining as employed by both of those investigators, Parr developed a special acid-resisting alloy for the construction of his calorimeter bomb. He presented two papers[3] at the Eighth International Congress of Applied Chemistry, held in New York in 1912.

A third paper[4] of special interest in this connection presented at the same Congress, gave a considerable amount of data confirming the value of the new alloy. This new Alloy was given the name of "Illium," and evidence as to its value in calorimeter use has been cumulative throughout the years which have followed its introduction. It is not uncommon for users to report an unblemished character, both inside and out, after years of service. One operator mentions the use of his Illium bomb in approximately 45,000 determinations without evidence of corrosion or deterioration of any sort.

It would be too long a story to enumerate all of the illustrations confirming the value of this alloy and indeed its complete equivalent as a substitute for platinum in the construction of bombs for calorimetric use.

[3]A New Alloy with Acid-Resisting Properties, and a New Calorimeter Bomb, with Special Advantages as to materials of construction and Method of Operation.

[4]Dr. Richard H. Jesse. Some Tests on a New Calorimeter Bomb.

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Calorimetry, Its Importance and Practice In The Gas Industry

*W. E. Stackhouse**

IN the manufactured-gas, as well as in the natural-gas, industry, the measurement of heating value is one of the most important measurements incident to the final distribution of such gas. In the manufactured-gas industry especially, a proper control of the quality is obtained only through an accurate determination of the calorific value.

Within the last few years calorimetry has become of equal importance in the natural gas industry also. This is largely due to the interconnection of natural gas distribution systems, because a proper knowledge of the quality is just as important as an exact measure of the quantity of gas so transferred.

Another rather recent development, making calorimetry more necessary to the natural gas industry, is the problem of "mixed" gases, in which the natural gas is mixed with some kind of manufactured gas, such, for instance, as coal gas or perhaps blue water gas. Hence, where such mixing is done, a careful check on the heat units contained in unit volume of gas, which represents money to the manufacturer, is important, while on the customer's side it is to his advantage that he receive gas of a constant quality. This implies a gas having a constant heating value and a constant specific gravity, and of these two the constant heating value may perhaps be said to be the more important, because a variation in the heating value of any gas affects the heat unit delivery to an appliance directly, whereas a variation in the specific gravity affects the heat unit delivery only inversely as the square root of this gravity.

Therefore, realizing the value of proper control of the calorific value of all gas used either domestically or industrially, we may consider some of the problems relative to calorimetric practice with more interest.

Briefly stated, calorimetry is the process of measuring quantities of heat. However, before any quantity can be measured a proper unit must be devised. A quantity of heat may be expressed by any of its directly measureable effects, the most convenient of which is the alteration of temperature when a source of heat is applied. Quantities of heat may thus be defined by stating the temperature to which they are capable of raising a known weight of a known substance, such, for instance, as water. The "thermal unit" is such a comparative unit, its value depending upon the units of mass and of temperature adopted.

As suggested above, in order to define a purely thermal unit of heat it is logical to choose some effect which heat produces, and then agree that this thermal unit shall be such an amount of heat as will produce a specified amount of this effect in unit of some "standard" substance. The specified effect which has been agreed upon is a change in temperature of 1°C per gram of the "standard" substance, which for convenience is taken as water. However, due to the change in the specific heat or heat capacity of water with a change in temperature, the particular range over which this heating shall occur must be specified. Now the specific heat of water is unity at a

*The United Gas Improvement Company, Physical Laboratory, Philadelphia, Pa.

temperature of 15.0°C (59.0°F), and for the sake of standardization the thermal unit called the calorie is defined as that quantity of heat which will raise the temperature of one gram of water from 14.5°C to 15.5°C. This is known as the 15° or small calorie.

Sometimes the mean calorie is also specified. The mean value of the specific heat of water between the temperatures of 0° and 100°C is 1.00012, hence the mean calorie, which is one one-hundredth of the heat required to change the temperature of one gram of water from 0° to 100°C, is actually 1.00012 calories (15°). Then too the "large" calorie, which is 1000 calories, is sometimes used as the comparative unit. However, in engineering practice in English speaking countries, the "British Thermal Unit" or "B. t. u." is used. This is defined as the heat required to raise the temperature of one pound of water one degree Fahrenheit. As with the calorie, the particular range is specified. Hence, converting degrees Centigrade to degrees Fahrenheit, we have this range as from 58° to 59°F. Then, for purposes of conversion, one B. t. u. equals 252 calories (15°), this value being derived from the relations existing between the pound and the gram and the degree Fahrenheit and the degree Centigrade.

The operation of measuring quantities of heat may be performed by either of three ways, namely, by the method of mixtures, by the method of continuous flow or by the method of latent heats. Of these three the method of continuous flow is the one most often used to determine the heating value of liquid or gaseous fuels, while the method of mixtures finds application in the form of bomb calorimeters, which are used to determine the amount of heat available from solid fuels, such as coal or coke.

Perhaps the simplest method of measuring certain quantities of heat is by the method of mixtures. In this process the quantity of heat to be measured is transferred to a known mass of the "standard" substance water, and by observing the temperature rise, the quantity of heat is readily calculable. The heat may be transferred to the water in a number of ways, as, for example, a piece of hot metal may be dropped into the water, or some hot liquid may be poured into it, or a hot gas may be passed into it. If the water for such experiments is maintained at a temperature near that for which the calorie or B. t. u. is defined, then the mass of water multiplied by the number of degrees rise in temperature will give the number of heat units added, after allowing for the known corrections for the particular instrument used. Sometimes it is advisable to keep the hot body from making direct contact with the liquid, in which case it may be put into an inner vessel having thin walls of good conducting material. Moreover, in some cases it might prove inconvenient or difficult to use water as the standard or calorimetric substance, in which case some other liquid or even a solid of known specific heat could be used.

In contrast to the above method of mixtures in which a "closed" vessel filled with a certain mass of water is used, we have the method of continuous flow, which in some cases is more readily adapted to the measurement of large quantities of heat. This method of continuous flow is particularly useful in determining the heats of combustion of gaseous and liquid fuels, where a constant rate of combustion may be had, and, hence, a steady liberation of heat can be maintained.

Fig. 1 is presented to show the set-up of a standard flow calorimeter as used in gas calorimetry.

In the operation of such an instrument a steady stream of "standard" substance, usually water maintained at a constant temperature, from a reservoir is allowed to flow past the point at which the heat is being liberated, thence caused to circulate, as shown in Fig. 2, in such a way that all the heat is absorbed by the liquid, and finally past the exit water thermometer. If the rate of liberation of heat is constant and the rate of water flow is constant, the temperature difference between inlet and outlet water must of necessity be a constant value. Hence, the number of heat units liberated when a certain quantity of fuel is thus burned, can readily be determined by noting the temperature rise and the mass of water which passes through the instrument while this volume of fuel is consumed.

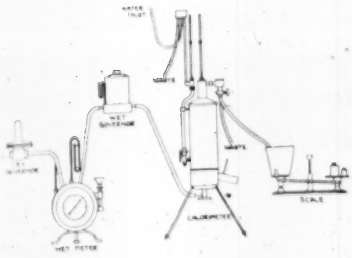


Fig. 1

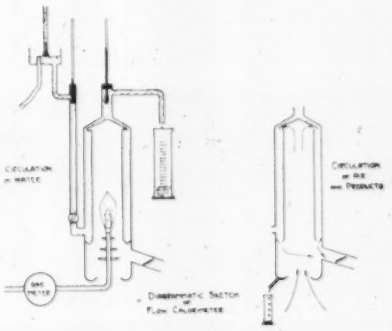


Fig. 2

Fig. 2 is a diagrammatic sketch to show the course of the water and of the products of combustion as they pass through a flow calorimeter. It will be observed that the gas and liquid travel through the instrument in such a way that all of the heat is transferred from the gaseous products to the liquid before the products escape to the atmosphere. The tubes are made of thin brass or copper, so as to get efficient transfer of heat, and for this reason should be kept clean at all times.

Actually, however, even though the instruments are designed in such a way as to give a constant effective head of water pressure to the heating tubes, it is impossible to get a constant flow. Furthermore, it is impossible to maintain the other primary variable, namely, liberation of heat, entirely constant. Hence, the resultant temperature increase between inlet and outlet water is subject to slight variation. Therefore, the standard procedure is to operate the calorimeter a sufficient length of time for it to attain thermal equilibrium, after which continuous observations of temperature rise are made while a certain volume of gas is burned. The water which flows through the instrument while these series of observations are made is collected and weighed. These three primary observations, when corrected, will thus make available the heating value of the gas so burned.

The determination of quantities of heat by the method of continuous flow may be subject to considerable error unless a careful consideration of all the factors affecting such errors is given. Briefly stated, these sources of error are eight in number and are as follows:

1. Completeness of combustion.
2. Temperature measurements.
3. Heat losses from calorimeter, or efficiency, which is affected by:
   a. Surface losses.
   b. Position of burner in the calorimeter and use of radiation shields on burner.
   c. Conduction down stem of burner.
   d. Heat carried off by products of combustion.
   e. Effect of atmospheric humidity.
4. Temperature of inlet water.
5. Constancy of flow of water and gas.
6. Time required for the attainment of thermal equilibrium in the calorimeter.
7. Weighing or measuring the water.
8. Measurement of volume of gas.

Although the above list of sources of error in using a flow calorimeter may sound quite formidable to anyone not familiar with their operation, it is enough to say that, in the actual procedure of determining the calorific value of a sample of gas with a standard flow calorimeter, the efficiency is or can be held very close to 100% by keeping the instrument well cleaned and polished. The inner and outer surface conditions of the calorimeter may affect the heat losses from the instrument to the greatest extent. The losses due to 3-b and 3-c may be reduced almost to zero by the use of radiation shields on the burner, and, as for 3-d, if the flow of products of combustion through the instrument is regulated by means of the exit-gas damper in such a way that the products leave the instrument practically at room temperature, no appreciable heat losses will be introduced through this cause. The effect of atmospheric humidity upon the heating value determination for the usual atmospheric conditions is a very small percentage of the total heating value. These humidity correction factors can be found in any work on calorimetric technology.

This effect may, however, become appreciable under certain exceptional conditions. A rigorous discussion of the part that atmospheric humidity and the hydrogen content of the burning gas have upon the total, gross and net heating values is given by Dr. Edw. B. Rosa in the Journal of the Franklin Institute of August 1912, pages 172-175, and its study is recommended to students of calorimetry.

No errors need be introduced due to incomplete combustion, because of the very good burner design which is now possible, and with calorimeter thermometers, which have been carefully calibrated, no errors in temperature measurements need creep in.

In a well designed calorimeter installation, where a reservoir of water is used, the water can be maintained to within a few tenths of a degree of room temperature. If the water differs appreciably in temperature from that of the room, a correction should be applied. The Bureau of Standards "Technology Paper No. 36" contains such a table of correction factors for differences in inlet water temperature as well as other invaluable data for anyone interested in the technic of flow calorimetry. The above statement of possible errors affecting calorimetric determinations is a partial list of those appearing in Technologic Paper No. 36.

The flow of water through a standard calorimeter may be kept quite constant, due to the design of the instrument, because of the inlet water overflow weir, whose function is to deliver water to the instrument at a constant effective head. The gas flow can also be quite easily regulated by means of standard flow governors.

When using a calorimeter, the instrument should be operated a sufficient length of time previous to making observations, in order that it will have attained thermal equilibrium. The importance of this should be quite self-evident. It is further obvious that the water which flows through the instrument during a series of measurements should be carefully collected and weighed, because this, it will be remembered, is one of the three fundamental measurements in connection with flow calorimetry.

The careful measurement of the volume of gas used during the determination of the heating value of a sample of such gas is also of vital importance. A laboratory wet test meter of one-tenth cubic foot capacity per revolution may be used, since this type meter, when carefully levelled and if in good condition otherwise, is capable of very precise calibration, and a volume of one one-thousandth of a cubic foot is measurable. The observed volume of gas used is usually corrected to that at standard conditions of 60°F and 30"Hg. barometric pressure by applying a correction factor determined by the observed gas temperature and the prevailing barometric pressure.

Still a third method of measuring quantities of heat may be used, namely, the method of latent heats, in one form of which the quantity of heat to be measured is used to melt a known quantity of ice. Such a method necessitates a knowledge of the heats of fusion of common liquids, but as in the case of this ice calorimeter, there is a great advantage in that the instrument remains at a constant temperature, 0°C. The most common instrument of this type is the Bunsen ice calorimeter. A second form is the Joly steam calorimeter, in which the order of temperature is reversed and the amount of heat required to raise the temperature of a known mass of substance over a certain range is determined from the amount of steam which is condensed in producing such a change of temperature. This requires a knowledge of the latent heat of steam under different conditions, but is a very convenient method for some applications.

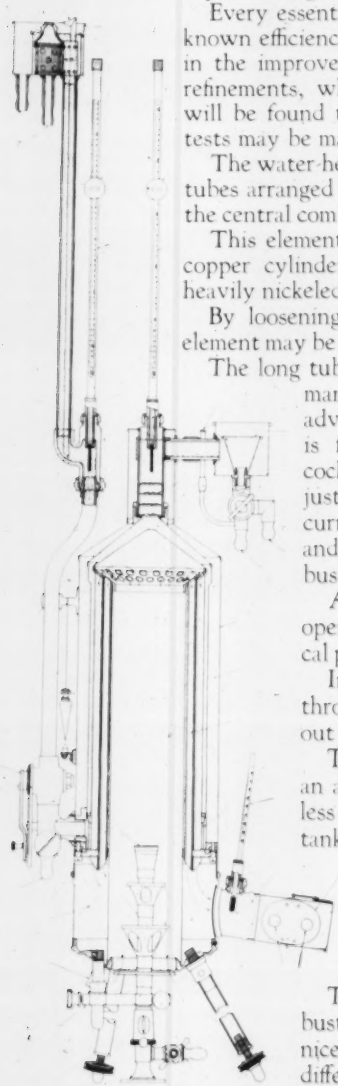
The above discussion has considered the fundamentals of hand calorimetry which is capable of very precise measurements, but the gas industry of to-day is faced with the situation, which has prevailed for the past several years, of measuring calorific values of large quantities of gas rapidly, continuously and with accuracy. Therefore, to meet this problem very ingenious, automatically recording calorimeters have been devised which will determine the heating value of a quantity of gas, fully corrected, within an accuracy of one per cent or better usually, and will maintain this accuracy for a considerable period of time with very little service required. However, it should be borne in mind that such automatic calorimetry is a mechanical adaption of any one or all of the three fundamental methods of calorimetry.

Descriptions of the Gas Calorimeters are given on the following pages.

The American Calorimeter

(American Meter Company)

THE improved American Calorimeter, embodies all the fundamental principles which are responsible for the high esteem in which the original Junkers and Hinman-Junkers instruments are held by technical experts and gas engineers.



Every essential feature which contributed to the well known efficiency of the original design has been retained in the improved instruments, while many changes and refinements, which have met with universal approval, will be found to aid greatly to the facility with which tests may be made and heating values determined.

The water-heating element consists of 48 tinned copper tubes arranged in two staggered concentric rows around the central combustion chamber.

This element is jacketed by a double-walled, vertical copper cylinder, tinned inside to resist corrosion and heavily nickeled and polished outside to limit radiation.

By loosening twelve cap screws, the entire heating element may be readily removed for cleaning or inspection.

The long tube Bunsen burner is a real triumph in the manufacturing art and marks a distinct advance over all previous types. The burner is furnished with 2 gas tips, micrometer cock and stand and is equipped with 3 adjustable baffle plates which limit eddying air currents and prevent downward radiation and consequent loss of heat from the combustion chamber.

Adjusting screws in the legs enable the operator to put the instrument in true vertical position as indicated by a small plumb bob.

In operation, water enters the calorimeter through an inlet weir at the left and passes out through a similar weir at the right.

The function of these weirs is to maintain an absolutely uniform head of water regardless of any variation of depth in the supply tank.

The flow is adjusted through a micrometer cock on the inlet and is passed to the weighing bucket or diverted to the waste through a 3-way cock on the outlet.

The escape of waste products of combustion may be regulated to an extreme nicety (at the point where the greatest difference in temperature is observed) by means of a pointer fitted to the axis of the damper, the position of which is clearly indicated on a graduated arc mounted on the exhaust tube.

The temperature of the inlet and outlet water may be conveniently read on thermometers graduated in tenths of degrees. These thermometers are set close together and at the same level, which greatly facilitates rapid, accurate observation. To reduce breakage and in order that mercury chambers may always be maintained at the proper depth, the thermometers are now set in screw sockets instead of rubber stoppers.

The manager of a gas plant can place the American Calorimeter in the hands of any employee of average intelligence and be assured of securing tests which will accurately reflect manufacturing conditions and which should lead to increasing economy and decreased cost of production.

The records of such tests, when carefully dated, signed and filed, will prove invaluable in case of unwarranted attack as to heating value of the gas furnished and in conjunction with recording pressure charts they will serve as competent and unimpeachable evidence of service before any court, public service commission or other regulating body.

The Löffler Caloriscope

(*Alpha-Lux Co., Inc.*)

THIS calorimeter has been designed for the rapid and accurate determination of the calorific value of gases. It offers a number of advantages over other forms of portable calorimeters, as it can be used for gases of all calorific values from about 80 B. t. u. per cubic foot upwards.

It contains an explosion chamber insulated by means of a Dewar vacuum flask, and the principle of design is the rise of temperature obtained in this explosion chamber by the combustion of a definitely proportioned mixture of the air and gas to be tested. This rise of temperature is measured on a thermometer whose bulb is fixed in the explosion chamber. The explosion is obtained by means of a high voltage (10,000 volt) spark from a small pocket battery and an induction coil. This battery also serves to operate a small lamp which illuminates the thermometer scale.

The following are the principal advantages of the Löffler calorimeter:—

1. It is portable and weighs less than 10 lbs.
2. It is accurate, the accuracy under ordinary conditions being within 0.35%, and if special precautions are taken within 0.1%.
3. A small quantity only of gas is required for each test.
4. No water connection is required.
5. A test of any gas can be made in two minutes.
6. No special training is required for the operator.
7. It does not require standardizing, and is carefully calibrated before being sent out.
8. The calculations required are very simple, as it is only necessary to multiply the temperature rise by a factor according to the measuring pipette used, and to make the ordinary corrections for gas temperature, and barometer readings in order to obtain the calorific value of the gas under standard conditions.

Six measuring pipettes are supplied with each instrument, numbered 00 to 4, having various capacities suitable for different qualities of gas, the largest capacity being used for gas of lowest calorific value. Corresponding to each pipette there is a factor by which the temperature rise must be multiplied to give the calorific value of the gas.

The operation is very simple.

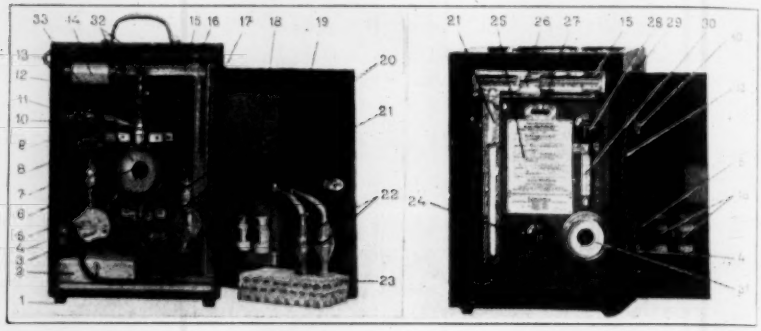
The gas to be tested after measuring by the most suitable of the pipettes is swept into the bomb by air. After closing the bomb by means of a stopcock it is exploded and the rise in temperature observed by means of a differential thermometer. After making the necessary corrections for gas volume by correcting for temperature and barometer pressure the corrected rise in temperature is multiplied by the factor given for the pipette used. The results thus obtained are calories per cu. meter. Multiplying the cal-

ories per cu. meter with the factor .1048 which is the factor for converting cal. per cu. m. gas saturated at 760 m. m. and 32°F. to B. t. u. per cu. ft. gas corrected to 60°F. and 30″M.

The apparatus is accurate to a very high degree if properly manipulated and can be used on almost any gas by simply changing the pipette.

It is convenient to carry and can be used at any point around the works or in the districts where for some reason or other a heating value determination seems advantageous.

The illustrations show clearly the construction of the apparatus. The various parts are indicated by numbers, which are referred to in the following list of component parts:

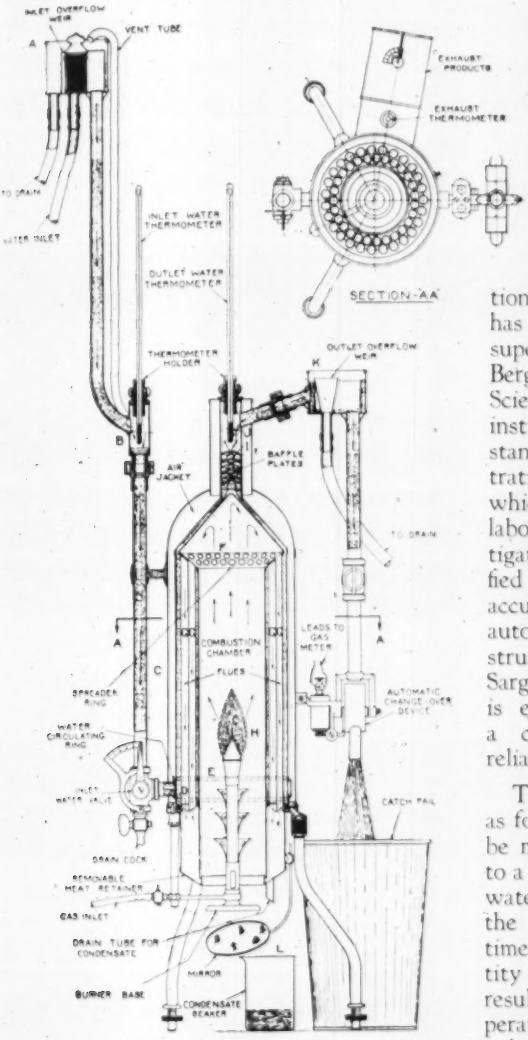


1. Rubber feet.
2. Box containing ordinary flash lamp battery.
3. Barometer with adjusting screw.
4. Buttons for ignition (black) and for thermometer lamp (white).
5. Capillary tube of measuring pipette.
6. Dewar vacuum flask and explosion chamber.
7. Measuring pipette (interchangeable) in working position.
8. Clamp for attaching pipette when making tests.
9. Rubber ring retaining barrel of cock in position.
10. Gas connection and filter for dusty gas.
11. Control cock No. 1.
12. Lead-in connections for spark.
13. Ring for raising and lowering levelling bottle.
14. Induction coil.
15. Explosion thermometer.
16. Guide pulley for chain operating levelling bottle.
17. Guide for levelling bottle.
18. Bottles containing grease for making joint between pipette and apparatus, and for cocks, and cotton wool for filters.
19. Removable doors at front and back of calorimeter case.
20. Mercury contact switch interlocked with cock No. 2.
21. Levelling bottle and stand pipe.
22. Measuring pipettes.
23. Container for pipettes.
24. Cock No. 2.
25. Factor table for pipettes.
26. Movable lens for magnifying readings on thermometer scale.
27. Argon control lamp showing passage of spark current.
28. Cock No. 1.
29. Aperture for chain operating levelling bottle.
30. Thermometer for indicating room temperature.
31. Aneroid barometer—front view (see No. 3).
32. Lamp for illuminating explosion thermometer.
33. Window in Dewar flask.

Sargent Gas Calorimeter

(Precision Scientific Company)

MORE than 20 years of continued research and experimentation have entered into the development and perfection of the Sargent Gas Calorimeter, the original Junkers Flow Type instrument to be made in this

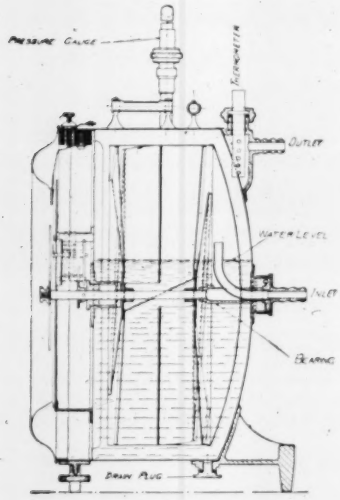


"Cross-Section of Calorimeter"

country — introduced by Mr. C. E. Sargent, member of the American Society of Mechanical Engineers, in a paper presented to that body in 1907. Since that time, refinement in design and construction of the instrument has been under the direct supervision of A. M. Berg, of the Precision Scientific Company. The instrument is an outstanding example illustrating the extent to which heretofore complex laborious scientific investigations may be simplified with no sacrifice of accuracy. Where entirely automatic recording instruments are used, the Sargent Gas Calorimeter is employed to furnish a check against their reliability.

The principle is briefly as follows. The heat to be measured is imparted to a continuous stream of water flowing through the calorimeter in the time that a known quantity of gas is burned. The resulting change in temperature of the water; the volume of gas burned to produce that change—with corrections applied, provides the data for calculating the calorific value of the gas. This result, when obtained through the use of the Sargent Calorimeter, is expressed directly in B. t. u., since the quantity of gas consumed is measured in cubic feet; the water is weighed on balances reading in hundredths of a pound; and Fahrenheit thermometers are provided, graduated in 1/10° intervals.

A Sargent Wet Test Meter measures the volume of gas used, which is supplied at constant pressure by a wet type pressure regulator. The use of both wet meter and regulator insure saturation of the gas with water vapor at



Cross Section of Meter

room temperature—one of the specified conditions for a calorific determination. Air necessary to support combustion enters through the open bottom of the calorimeter, while the exhaust gases issue through a dampered opening in a specially constructed heat retainer. Manipulation of the damper to regulate the velocity of exhaust gases assures complete combustion. The gas is burned in a bunsen burner furnished with six removable orifices adapted to the combustion of gases ranging in heating values from 100 to 2200 B. t. u. Tests conducted at the Bureau of Standards with a flow calorimeter using a Bunsen burner, indicated thorough combustion, as evidenced by no variation in heating values obtained, when the ratio of air to gas used varied from 7 to 1, to 20 to 1.

The products of combustion rise to the top of the water jacketed combustion chamber, and are deflected down through a series of tubes immersed in the flowing water. Thus the heat energy originally contained in the gas is imparted to the water, and the products of combustion are cooled, after which they are expelled from the calorimeter and their exhaust temperature noted by a thermometer inserted in the heat retainer, which is designed to collect the condensed water of combustion, and to deliver it into a metal beaker for determination of the net heating value.

Where previously it was the duty of the operator to divert the outlet water at exactly the right instant, electric manipulation of tipping buckets has been introduced. For every tenth of a cubic foot of gas passed through the meter, the exact amount of water flowing through the calorimeter during the time in which that gas is burned, is automatically diverted into one of the weighing pails. The meter index, at the instant it strikes the zero position on the dial, completes an electrical circuit, thereby energizing an electro magnet, the armature of which releases the double compartment tipping bucket on the calorimeter, causing a diversion of the outlet water flow. Thus the pre-determined unit of gas is one-tenth of a cubic foot, and subsequent calculation of the heating value, relative to a cubic foot of gas, is reduced to a shifting of the decimal point. The device, thoroughly automatic, consistent in operation, eliminates a large element of personal error.

The use of this feature is controlled by a convenient switch on the meter, and may be utilized by proper manipulation of the switch, to effect water divergence for any multiple of 1/10 of a cubic foot, dependent on the heating value of the gas used. The automatic tipping bucket device is instantly removable as a complete unit, and is interchangeable with a swinging spout, additionally furnished for manual changeover.

A correct and uniform rate of water flow is maintained by the inclusion of constant level cups in both the inlet and outlet weirs, with an indicating quadrant valve interposed between the inlet weir and circulating chamber.

Inlet and outlet thermometers are placed at the same height to facilitate reading. A vent tube eliminates pocketing of air around the bulb of the former; baffle plates insure thorough mixing of the outlet water in proximity to the bulb of the outlet thermometer.

Radiation shields fitted to the burner tube, employment of the special heat retainer, and the housing of the calorimeter body in a highly polished, nickel plated shell, air insulated from the water jacket—results in the reduction of heat loss to a negligible quantity. The heat—absorbing efficiency of the calorimeter, when tested with an electric heating coil of known effect, has been shown to be 99.6%.

Ease of cleaning is afforded by the constructional arrangement. The flue tubes are completely exposed by dissembly of the insulating shell, which requires the removal of only nine accessible screws. Both inlet and outlet weirs, heat retainer and legs, may be separated instantly from the calorimeter body.

Every refinement, of which there are many, is conducive not only to greater accuracy and efficiency, but adapts the instrument to the needs of industry for a calorimeter capable of simple operation in the hands of the layman.

The Burgess-Parr Recording Gas Calorimeter

(Burgess-Parr Company.)

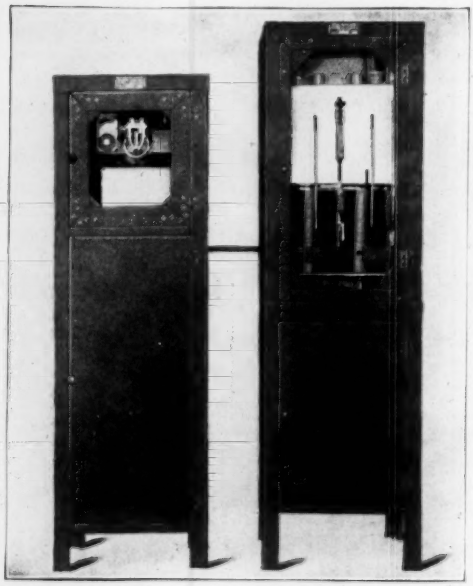
THIS calorimeter is used for the determination of the heating value of combustible gases, and can also be used to control the B. t. u. content. It is the result of several years of development work conducted by Professor S. W. Parr and associates, combined with several basic features introduced by the Doherty Research Company.

It is continuous in operation, and automatically actuates a temperature differential recording mechanism to produce a permanent record directly in B. t. u. s per cubic foot of gas at standard atmospheric conditions. It is of the flow type, in which water is employed as the medium to absorb the heat produced by combustion of the gas.

Both the gas and water are automatically measured in carefully calibrated measuring chambers. The gas is measured by its displacement with water, thus eliminating the usual rotary wet meter with its unavoidable errors. The water is measured by its rise into the measuring chambers, (effected by means of gravity), to a certain level, at which point a float causes a mercury switch to close a circuit, thereby opening a valve and permitting the exact quantity of water to flow to the heat extracting chamber. A double set of measuring chambers provides continuous measuring of both gas and water, so that there is no interruption in their flow through the instrument. The chambers are so calibrated that the rise in temperature of the water flowing through the heat extracting unit is .01 part of the B. t. u. content of the gas.

The temperature rise is noted by two sets of thermometers, one, a pair of carefully selected mercurial thermometers, and the other, electrical resistance thermometers, used in the operation of the recording mechanism. The mercury thermometers provide a ready and accurate means of checking the accuracy of the recorder, thus obviating the necessity for running a

"cold balance" (operating the calorimeter with no gas burning in order to check the zero point). The recorder is the temperature differential recorder manufactured by the Leeds and Northrup Company.



The water used in the calorimeter is kept at a uniform temperature by means of thermostatically controlled cooling coils connected to a small supply of flowing water. Careful insulation of the heat extracting unit eliminates errors which might be caused by variations in room temperature. Because of this constant temperature of the water and insulation to prevent radiation, the rise of temperature of the water flowing through the calorimeter is directly proportional to the heating value of the gas.

Correction for changes in atmospheric pressure, and the small variations which may occur in the temperature of the measured gas, are automatically made by a mechanism which varies the water to gas ratio directly with the changes of the quantity of gas due to the variation in its temperature and pressure. In this way, these variations are automatically compensated, and the record produced on the recorder chart gives the total heating value of the gas being tested in British Thermal Units per cubic foot of gas at standard conditions of pressure and temperature.

The Burgess-Parr Recording Gas Calorimeter possesses several advantages over other gas calorimeters, the most important of which is the continuous and accurate record which is automatically produced, and whose accuracy can be readily checked by means of the mercury thermometers. Another unusual characteristic is the relatively small lag in the operation of the instrument, i. e., the short time required before a change in the quality of the gas entering the instrument is noted on the record. The change is indicated by a movement of the recorder pen within two minutes of the time the change occurs, and the entire change is completely recorded in from seven to nine minutes. This is of especial importance when it is desired to control the calorific value of the gas either manually or by means of a regulating valve.

Other advantages may be listed as follows:

(1) The use of water as a heat absorbing medium is direct and exact, and conforms with the accepted definition of a British thermal unit.

(2) The calibration is constant, as none of the moving parts, which are subject to wear, can affect the accuracy of the instrument.

(3) The displacement of gas by water provides the most accurate method known for the measurement of gas volumes.

(4) The water measurement, being equally exact, eliminates the chance for error present in weighing processes.

The Thomas Calorimeter

(Cutler-Hammer, Inc.)

QUALITY measurement is of equal importance with quantity measurement for economical gas production. By close control of gas quality it is possible to effect economies in plant operation and improvements in service.

The Thomas Calorimeter provides close control by giving a continuous, accurate and reliable record of the total heating value in B. t. u.'s per cubic foot of gas at 30″ and 60°F. saturated without any manipulation, corrections or computations whatever. Thus executives, superintendents and those interested are enabled to check carefully performances, plan improvements, quickly correct faulty operations and maintain uniform quality.

The Thomas Calorimeter is used chiefly to determine and record the calorific value of water gas, coal gas, blue gas, producer gas, natural gas and mixtures of these gases.

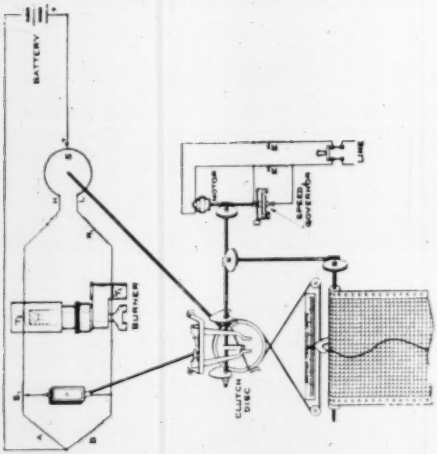
In operation of water gas machines, accurate and continuous knowledge of the heating value of the gas is of material assistance toward economical production in controlling the enrichment oil and cleaning of machines for coke oven and coal gas plants. More uniform quality of gas will result from pressure control in accordance with calorific values. It is further desirable to supply the fuel gas to coke ovens at such rates that a constant quantity of heat is supplied in unit time, necessitating continuous and reliable measurements as well as quantity measurements.

In present day practice many gas plants have a constant supply of purchased coke oven gas or coal gas of their own manufacture, with carburetted water gas being made of such quality and in such quantity as to control the heating value of the mixture and to care for peak load demands. Close control with other than continuous calorimeter records is impractical for economical operation.

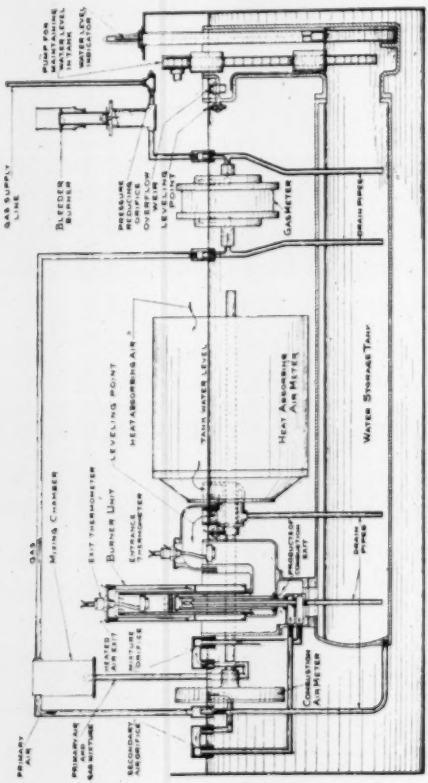
The Calorimeter is a self-contained instrument requiring no arbitrary settings from other calorimeter readings. The results are continuous and graphically recorded, and can be shown at one or more points in the plant as desired. Testing means are provided with the instrument to check readily its accuracy. Once properly set up the instrument will maintain its calibration for long periods, requiring only occasional oiling, replenishing of water in the auxiliary tank, cleaning the burner and changing recorder charts.

The heating value of the test gas is determined by imparting all the heat obtained from the combustion of the test gas to a stream of air and measuring the rise in temperature of the air from the heat absorbed. The streams of test gas and heat absorbing air are maintained in fixed proportion to each other by metering devices geared together and motor driven. Consequently the temperature rise produced in the heat absorbing air is directly proportional to the heating value of the test gas without regard to the actual rate of gas burning. This temperature rise is translated into B. t. u.'s per standard cubic foot and recorded graphically.

The use of air as the heat absorbing medium in the Thomas Calorimeter eliminates the necessity for making corrections for variations in room temperature and pressure since the heat absorbing air and heat imparting gas are



Wiring Arrangement of Thomas Calorimeter



Arrangement of Piping and Meters for Thomas Calorimeter

maintained at similar conditions and follow the same physical laws as to behavior with varying temperature and pressure.

The Thomas Calorimeter consists of 2 separate units—a tank unit or calorimeter proper, where the heating value of the gas is measured, and a recorder case containing the instruments recording the results.

In the calorimeter proper are 3 water-sealed displacement pumps or meters, geared together and motor driven. The gas meter supplies the gas for testing, the heat absorbing air meter supplies the air for absorbing the heat of combustion, and the small air meter supplies the air for combustion. Since all are geared together the air and gas are always delivered in fixed volumetric proportion. They are calibrated and adjusted to give a standard discharge although the gearing may be changed to provide any desired ratio for different classes of service. To insure the maintenance of the water level, a small pump raises water from an auxiliary tank inside the main tank, maintaining a circulation of water over the weir.

The sample gas enters the calorimeter through a small orifice and passes into a separate chamber open to the atmosphere through a bleeder burner. The orifice breaks the pressure, and the bleeder not only insures a fresh sample but it is of sufficient

area to prevent building up of any pressure in the chamber from which the gas is pumped by the gas meter. The gas at approximately atmospheric pressure is pumped through suitable piping to the mixing chamber, where it mixes with the air supplied by the combustion air meter. From there the mixture of air and gas enters the burner, where combustion takes place. To insure complete combustion, secondary air is supplied direct to the flame at point of combustion. The products of combustion then pass out of the bottom of the burner after having given up their heat to a stream of heat absorbing air. The direction of flow of the latter through the burner is counter to that of combustion gases. It will be noted that passages of the heat absorbing air are entirely separate from the combustion flues and to prevent heat losses a polished double walled tube is fitted around the burner jacket, which is in turn jacketed with the heated air.

The nickel resistance thermometers are connected with the recording instruments. The thermometers form 2 legs of a Wheatstone bridge, with 2 fixed resistances serving as the other legs. A slide wire resistance serves to balance the bridge, the amount of resistance necessary to bring about balance being an indication of the temperature difference between the 2 thermometers. Accordingly the position of the slide wire is an indication of the B. t. u. value of the gas.

In operation, the galvanometer needle is clamped periodically between 2 pivoted levers. Any deflection to the right or left of the neutral point indicates an unbalance of the system and causes these levers to operate a clutch mechanism which moves the slide wire the proper amount to again produce balance. The position of the slide wire is recorded on the chart in B. t. u.'s per standard cubic foot.

The Johnson Recording Gas Calorimeter

(Gas Producer & Engineering Corp.)

THE Johnson Recording Gas Calorimeter is an instrument for continuously recording the heat value of gas. Because of the fact that the majority of gas calorimeters are not automatic, requiring laborious calculating and reading to obtain the heat value it will serve a long felt want for an accurate automatic recording apparatus.

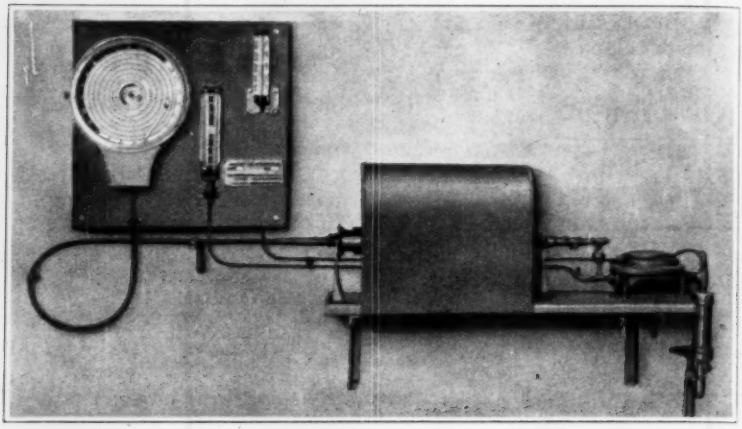
The gas producer operator without a means of determining the quality of his product cannot deliver a good gas continuously. A poor gas means wasted coal, wasted effort of labor and curtailed production. To insure against loss of these 3 essentials the gas producer operator should be able to determine instanteously the calorific value of the gas as it is being produced.

Because it is a recording instrument the trend of the gas quality is brought to the attention of the operator and enables him to rectify at once a condition that is the cause of poor gas. Furthermore it enables the operator to determine what operating methods and which fuels are the most effective.

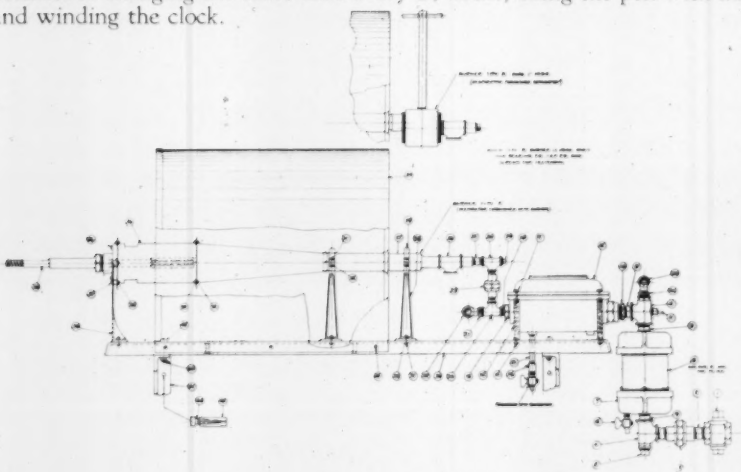
The instrument is provided with a time punch for showing the times per day that readings have been noted by the operator.

The Johnson Calorimeter is very sensitive and instantly records any slight variation in the quality of the gas. The dial of the instrument is 12" in diameter, consequently showing a large variation for a slight change in the thermal value of the gas.

Owing to the peculiar design and construction of this instrument it retains its accuracy after having been in continuous service, which is of great advantage over others on the market which lose their adjustment very rapidly and require frequent recalibrating.



The instrument is of rugged construction and simple with practically no moving parts. The attention required in operating the instrument consists in changing the chart once every 24 hours, filling the pen with ink and winding the clock.



It can be used for hot or raw gas as well as clean producer gas and especially serves a long felt want for hot type producers which heretofore have been dependent on the unreliable and inaccurate method of endeavoring to determine producer conditions by taking the temperature of the gas leaving the producer.

The gas is delivered to the calorimeter unit at line pressure and run through a special filter to the calorimeter governor or reducing valve. The gas is here reduced to a constant low pressure and delivered to the inspirator where it entrains the air for combustion. The heat of the gas flame and

products of combustion are carried through the horizontal cone past a special bulb which actuates the arm of the recording instrument. As the gas is considered to be at the same temperature, density and pressure at the inspirator, it will entrain a definite amount of air at all times, thus the volume of mixture entering the burner will be the same regardless of the B. t. u. value of the gas. If the heat value of the gas varies, the heat of burned products passing the bulb will vary and show on the chart. This chart has been carefully calibrated after a series of tests and in actual practice the readings have proven to be reliable and give a permanent record of the gas quality for future reference. The design of the instrument is such that it has only 1 moving part and consequently the maintenance cost is exceptionally low.

The instrument is manufactured for use with blast furnace gas, bench gas oil gas, water gas, coke oven gas and natural gas.

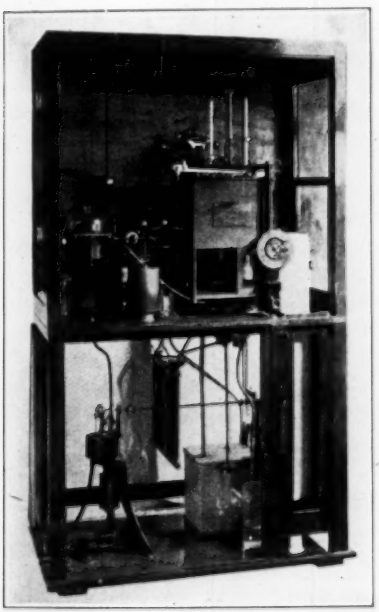
Boys Recording Gas Calorimeter

(Griffin & Tatlock, Ltd.)

THE Boys Recording Calorimeter is designed to obtain a continuous record of the gross calorific value of gas in relation to the volume, which the gas would occupy if it were measured at standard temperature and pressure, (60°F. and 30″ of mercury), and saturated with water vapor.

Bath water and gas are doled out positively at the correct rate, and the correction for gas volume as affected by temperature, pressure and contained water vapor, is also affected by a positive operation.

The Boys Recording Calorimeter is independent of outside water supplies in that means are provided for cooling and re-circulating the water which has passed through the various parts of the instrument. Water, distilled or well-boiled in the first instance, is pumped continuously from a lower tank, of about 10 gallons capacity, to an upper reservoir in the form of a shallow tray. The water is pumped at a rate greater than that required to supply the instrument, and the excess returns from the tray to the lower tank by way of an overflow pipe, which, being of glass, serves as an indicator of the adequacy of supply. From the upper tray the water passes by way of a gauze filter through a loop immersed in the water of the meter, to a nozzle from which it emerges in the form of a jet. The jet is intercepted at regular intervals by a measuring device which, when a certain quantity has been delivered, discharges this quan-



tity into the front compartment of a divided water-tray, after which the jet is directed into the back compartment of the tray.

The water from the front compartment of the metal tray passes to and through the calorimeter and is then discharged into the lower tank, on its way passing through a radiator cooled by a fan driven by a hot-air engine which also actuates the pump.

The water from the back compartment of the metal tray passes over a small overshot water-wheel which turns once every ½ minute, and which supplies the motive power to drive the escapement wheel of a clock, and also other mechanism controlling the measurement of the gas. It is then discharged into the lower tank whence it is pumped, together with the cooled calorimeter water, to the upper tray.

Water Measurement. The water passing to the calorimeter proper is doled out positively and accurately at ½-minute intervals by a tipping bucket carried pivotally on a counterweighted balance beam, which beam is supported in a condition of unstable equilibrium.

The weight of water delivered by the bucket is such that, for a given declared value, a rise of 10°, ensues when the gas, at its declared value, is burnt at a rate which corresponds to ½ cubic foot per hour under standard conditions.

This weight of water will therefore vary with the declared calorific value and can be determined by the application of the following simple rule:—

1. To the figure representing the declared value in B. t. u.'s per cubic foot, add 5% of itself.
2. Divide the result by 10.

The resulting figure, in grams, is the weight required. Thus, for a declared calorific value of 500 B. t. u.'s per cubic foot, the required weight is 52.5 grams. The balance beam is provided with a 10-sided counter-weight and a lock-nut upon a screwed tail. The counter-weight and lock-nut together weigh twice as many grams as the screw on which they are carried has threads to the inch, and the trunnion axis of the bucket is placed 2 inches from the knife edge of the balance beam; consequently 1 turn of the weight and lock-nut corresponds to 1 gram in weight of the contents of the bucket more or less according to the direction of turning. The faces of the decagonal weight are stamped 0 to 9, so that each unit of these numbers corresponds to 1/10 gram in 1 tilt of the bucket.

The water is delivered to the bucket in the form of a continuous horizontal jet, parallel to the axis of the balance, which strikes a tubular receiving spout attached to the lid of the bucket. When the correct weight of water is in the bucket, the balance beam falls and since the beam is in unstable equilibrium, when once it begins to fall, it does so with acceleration and the spout clears the water jet.

The movement of the balance beam is restricted by 2 stops, and in order that the balance may weigh correctly the bucket contents it is essential that the bucket should not tip or begin to tip on its own account until the balance beam has tilted and has been arrested by its upper stop.

Soon after the water begins to run out of the bucket, the latter tends to right itself and is then arrested by a pawl which engages the pouring lip

of the bucket. The pawl is disengaged and the bucket thus released, by the impact of a push rod actuated by the water-wheel, once every ½-minute.

The rate of water-flow from the nozzle should be so adjusted that the bucket is filled in from 14 to 15 seconds. The water delivered by the bucket passes out of the front compartment by way of a sunken orifice, and the flow from the orifice should cease shortly before the next bucketful of water is available. This intermittent flow insures that a definite quantity of water passes from the compartment and the effect of the fluctuation on the record is invisible.

Gas Supply. The gas is brought from the service pipe to a governor and thence to a T, where one portion passes to the burner of the hot-air engine and the other portion passes to the meter by way of a controlling orifice and a saturator. The governor should be so adjusted as to reduce the gas pressure to from 0.8-1.0″ water, and each arm of the T should be provided with a tap.

Gas Measurement. The Boys Bell Meter is of 1/40th cubic foot capacity It is designed to dole out the gas at the desired rate by positive volume measurement and at atmospheric pressure, and it is also its own governor.

Correction for Gas Volume. Correction for variation in gas volume is applied directly in the form of proportional variation of the meter rate.

The meter axle, and consequently the meter drum turns once every 3 minutes when the gas volume is 1.000. When the gas volume is greater or less than 1.000 the meter axle turns faster or slower, the acceleration or retardation being so controlled as exactly to compensate for the variation in gas volume.

The motion of the cylinder is determined by the position of a Hoffmann bronze ball which itself is determined by an air-ball over mercury and water.

The air-ball actuates a fork astride the ball, which moves backward and forwards along the trough formed by the cylinder and the face of the disc as the ball rises or falls.

The disc is turned continuously, and when the Gas Volume is 1.000 and no correction is necessary, the ball is located so as to rest against the center point of the disc. In these conditions no motion is transmitted to the cylinder, and the drive from the water-wheel to the meter axle is wholly through the epicyclic gearing, and the integrator is motionless.

If the ball is on the side nearer to the epicyclic shaft the cylinder will rotate in a counter clockwise direction, and, through this epicyclic gearing, will retard the axle rate, and vice versa.

For a change of gas volume of 10%, the ball moves 1 inch, equal to the radius of the cylinder, and in proportion for other values.

The fork which directs the rolling of the ball along the V-groove formed by the inclined disc and the cylinder of the thinking machine, carries a pen moving over a scale of gas volumes, so that the gas examiner can observe if the air-ball is correctly placed in its annular bath.

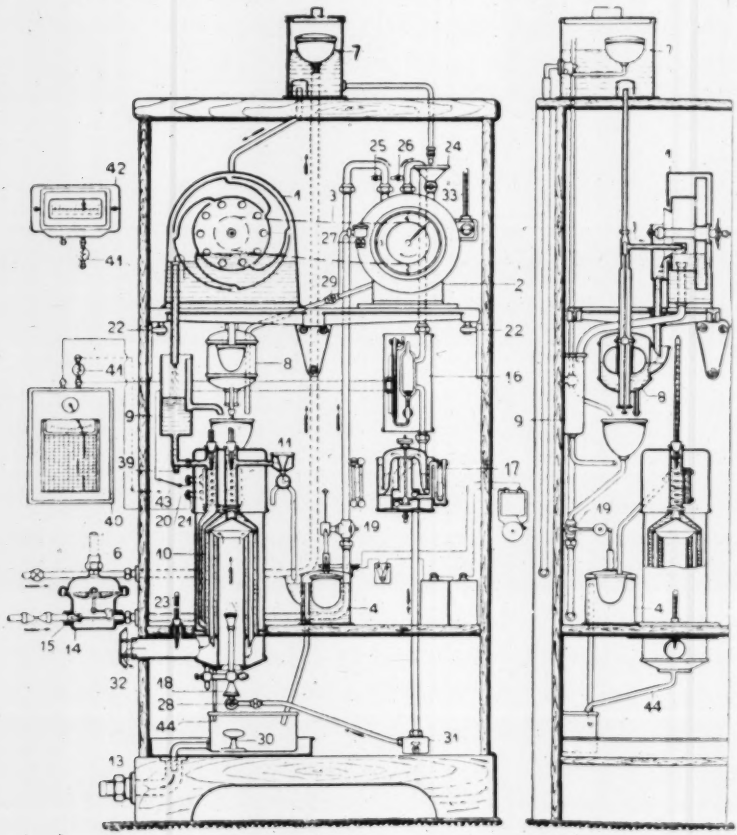
The scale of gas volumes is affixed to a recording drum with an epicyclic and worm drive which converts a rotation of one turn a minute into one of one turn a month. The circumferential lines on the record sheet are spaced at intervals representing 1%. the middle line showing the position of the pen when the gas volume is 1.000. When the gas volume is less than 1.000 the pen should be on the near side of the middle line and when greater than 1.000, on the far side.

Junkers Automatic Calorimeter

(Junkers & Company)

THE Junkers Automatic Calorimeter operates exactly like the simple calorimeter for gas and liquid fuels so that this description will be confined to the automatic calorimeter.

The heat set free by the burning of the gas is steadily imparted to a continuously flowing current of water. Thus all the sources of error of indirect



measuring instruments, especially to those as require adjustment by means of direct measuring apparatus, are avoided. The formula for determining the heating value is as follows:

$H = \frac{W}{G}$ td where H is the Heating Value, W is the Quantity of Water, G is the Quantity of Gas, and td is the Rise in Temperature.

Previously for the determination of the heating value, it was necessary to read the quantity of gas at the gas meter, measure the quantity of water, determine the rise of temperature of the quantity of water, by readings of the thermometer.

The Junkers Automatic Calorimeter is constructed so that the quotient W/G from the above formula, that is the ratio of the quantity of water to that of the gas, is constant. The heating value H—k x td is therefore a linear function of the rise of temperature td, the latter thus being a direct indication of the heating value.

The quotient $\frac{W}{G}$ is held constant by directly connecting the gas meter to the water meter, being specially constructed for this particular purpose in such a way that the burnt gas quantity per time unit or the gas quantity per revolution of the gas meter always corresponds to a certain quantity of water, flowing through the calorimeter and the change of one causes a corresponding change in the other.

The rise of temperature td, however, is not determined by reading the thermometer, but by means of thermocouples built into the upper part of the calorimeter (10), the hot ends of which lie in the current of cold and hot water. The direct reading is made from a calorific scale, on the galvanometer.

The use of the thermoelectric measuring system has the advantage that the reading can also be taken distance from the calorimeter and in several places at the same time.

A valuable attribute of the Junkers Calorimeter is the ease of control, i. e., the calorimeter itself also permits the determination of the heating value by the old method, consequently the determination of the quantity of water and gas and the rise in temperature of the water. The automatic indication may therefore always be tested for accuracy.

The instrument for continuous and automatic testing of the heating value consists of:

Calorimeter body (10) which surrounds the gas flame and completely transfers the developed heat to the current of water.
Water meter (1) and Gas meter (2), being directly geared are compelled to hold the relation between the quantity of gas and the quantity of water constant.
Supply regulator (7), which adjusts the flow of water, according to requirements.
Supply regulator (8), which provides for a very constant flow of water to the water meter.
Two gas pressure regulators (14) and (17), which hold the pressure on both sides of the gas meter constant within certain limits.
Thermocouple, fitted into the upper part of the calorimeter with two connecting terminals (20) and (21).
Two control thermometers, for the inflowing and outflowing water.
Safety-device (4), automatically shuts off the gas when the water supply fails.
Millivoltmeter (41) and (40), electrical indicator or recorder.

The water pipe must be connected at (6). The water flows to regulator (7) which regulates the quantity of flowing water. Another delicate regulation will be carried out by the regulator(8), whereupon the water runs into the water meter (1) and after passing through a comparison vessel (9) it flows into the calorimeter (10), where the water is being heated. The water proceeds into the safety device (4) through the pipe (11) and is discharged at (13). The circulation of the water is started and stopped by a cock at the front of the calorimeter case.

The gas is connected at (15); it passes through the pressure regulator (14) into gas meter (2) and from there to a second regulator (17), then to burner (18) which is placed into the calorimeter after lighting. The gas flow is started and stopped by gas cock (19). The thermocouple is mounted in the upper part of the calorimeter body (10); the terminal screws (20) and (21) are the cold junction.

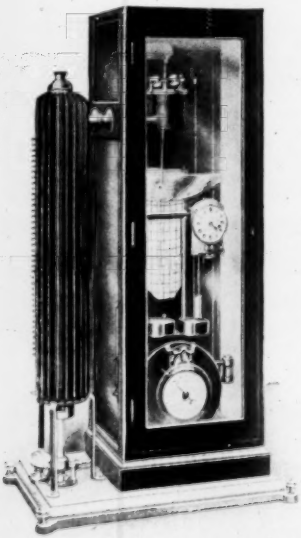
Safety-device 4 is installed to prevent damaging the Calorimeter by burning flame, in case the water is stopped for any reason. It also avoids the passage of unburnt gas when the gas comes on after an interruption in the gas supply.

The Beasley Recording Gas Calorimeter.

(Sarco Company)

IN previous gas calorimeters, the "high" value is ascertained and the "net" value is derived from the "high" value by condensing the products of combustion and measuring the water of condensation—a method which is distinctly liable to lead to errors. In this calorimeter the net value is ascertained direct.

Another important improvement is that this calorimeter records. It was one of the first recording calorimeters to be placed on the market, and when once started requires no attention beyond the periodical removal of the record chart and the winding of the clock once a week. The advantage of obtaining a continuous record without any trouble, over the old system of testing a sample of the gas once a day, with a good deal of trouble and care, is too obvious to need pointing out.



The principle of the calorimeter may be briefly summarized thus. The gas is burned within a well-radiated chimney, and the working of the calorimeter depends upon the fact that the average rise in temperature of this chimney is proportional to the heat developed by the flame. This chimney contains an annular chamber, which forms one limb of a U tube, the other being a simple tube maintained at atmospheric temperature. The U tube is filled with oil, and as both limbs terminate in tanks, it is possible, by means of floats and suitable pulleys, to indicate and record the difference in level between the two limbs of the U tube, caused by the expansion of the oil in the hot limb. The illustration shows the general design of the instrument, the chimney and the "cold" limb being connected through to tanks which are contained in a glazed and polished case together with the clock and paper gear and other apparatus, the whole being fitted on a cast iron base and back.

In a recording gas calorimeter it is obvious that the flow of gas must be automatically maintained at a constant and pre-determined rate, if accuracy is to be attained. To effect this, it is first necessary to control the pressure by means of governing apparatus, so that in spite of variations at the inlet of the governor, the pressure at the outlet remains constant. This in itself is not, however, sufficient, for if no other method of regulation were pro-

vided, the quantity of gas passing would be controlled by the size of the orifice whence it issues, and the pressure; and the rate of flow would consequently vary with the specific gravity of the gas, rendering the record of the calorimeter uncertain and misleading. To overcome this difficulty, a special regulating test-meter is provided, with the measuring drum geared to a pendulum escapement. The drum of the meter drives this escapement just as the spring of the clock drives the clock, and in the same manner as a clock escapement controls the speed of the clock, so the escapement attached to this meter controls the speed of the drum, thus ensuring a constant rate of flow, unaffected by variations in specific gravity, or, in fact, any other slight fractional or pressure variations in the apparatus.

The analysis of a sample of the gas, or the making of a single test of its calorific value, may give some idea of the quality of the gas at the moment the sample is taken, but the recording calorimeter shows accurately what the quality of the gas has been all the while, from the time, the trouble began until it ended, and onwards.

The instrument is as well adapted for producer as for coal gas, only a few modifications being necessary. In the first place, the calorific value of producer gas being much less than that of coal gas, a larger quantity is used, and the regulating test is, consequently, of considerably larger capacity, while the governing apparatus is of a different type, and is specially designed to facilitate cleaning, should the working parts become clogged with deposit. For the same reason the connections are all of ample bore. It is, of course, necessary to prevent, as far as possible, tarry vapors condensing in the apparatus, and this may be done in any convenient manner, but, if desired, a small scrubber can be sent with the calorimeter. If reasonable precaution is taken, there should be no trouble on this score, as the instrument is so designed that any moderate amount of condensation will not effect its working.

The calorimeter is also made without recording mechanism, to indicate only, by means of a pointer and a scale, and this form is arranged both for producer and coal gas. The clock and paper-driving mechanism are, of course, omitted, but in other respects the calorimeter is exactly the same as the recording instrument. Where the indicating instrument is in use, it should be kept running, and in this way the calorific value of the gas can be observed at any time, although of course no permanent record is made.

Below are given descriptions of Bomb Calorimeters.

Baird & Tatlock Bomb Calorimeter

(Baird & Tatlock, Ltd.)

THIS calorimeter embodies several new features which make for increased ease and efficiency in working. Among them is especially mentioned the following:

1 All metal parts of the bomb including terminals, valve spindle, unions etc., are made of highly polished stainless steel.

2 An improved method of forming the joint between cover and bomb entirely dispenses with the use of a heavy metal spanner. After screwing

on the cover a slight twisting movement with a small pin spanner is all that is necessary to assure a perfectly gas tight joint.

The Bomb is in 3 separate pieces with all metal parts including ignition wire and crucible supports, terminals, valve spindle, etc., formed entirely of stainless steel. Every part both inside and outside the bomb being worked perfectly, smooth and highly polished. The cover is held on by a union nut so as to avoid rotation and tearing of the joint ring and is provided with a series of slots around its periphery for the pin spanner. The inside surface of cover and upper edge of the body are backed by a tongue and groove joint provided with a patent composition washer, and the merest turn of the cover ring by means of the spanner is sufficient to render the bomb absolutely pressure tight. The cover carries the supports for crucible and ignition wire, and oxygen admission valve, and insulated firing plug, and two terminals for connection of the battery wires. The crucibles and wire supports consist of stout stainless steel rod fitted with a special device for quickly and securely fixing the ignition wire in position. The admission of oxygen is controlled by an improved form of fine adjustment valve which is fitted with a stout spindle terminated by a large milled head.

The connections between oxygen cylinder and bomb consist of thick walled copper tubing fitted with unions, pressure gage on stand and fine adjustment valve with union for oxygen cylinder.

The containers consist of an inner polished copper cylinder mounted on an insulated stand and a large water jacketed outer vessel felt covered or chromium plated as described on which is mounted the stirring gear, the stirrer being arranged to work either by hand or power. An ebonite cover with 2 terminals and a fixing key is fitted to the outer container and provides a convenient means for making connection between the bomb and ignition battery. The inner vessel contains a stainless steel frame on which to stand the bomb in order to keep it from contact with the bottom and slides of the vessel. Fittings to hold the thermometer and reading lens are carried on one of the vertical rods.

The Burgess-Parr Oxygen Bomb Calorimeter

(Burgess-Parr Company)

THE Burgess-Parr Oxygen Bomb Calorimeter, either the standard or adiabatic type, is a recognized precision instrument for making calorific determinations of solid or liquid fuels, foodstuffs, or other combustibles. It is a modification of the Atwater type calorimeter, in which a weighed quantity of the material being tested is ignited in an atmosphere of compress-

ed oxygen, the resultant heat being absorbed by a known quantity of water, the rise in temperature of which is determined by a special calorimetric thermometer, from which is calculated the heating value of the combustible. The instrument meets the specifications of the American Society for Testing Materials, 1927, Serial Designation 271-27, and has found wide application in American industry.

Oxygen Bomb Calorimeter, Standard Type. The outstanding feature of this Oxygen Bomb Calorimeter is the bomb, which is made from a solid casting of Illium, an alloy developed primarily for this purpose. The combustion of fuels, especially coal, in an atmosphere of oxygen, generates both nitric acid and sulphuric acid, thus making it essential that the bomb be constructed from some material which will withstand corrosive attack. Illium is such a material, and has the added advantages of great strength and machinability.

The use of Illium for the construction of the bomb eliminates the necessity for linings, which, at best, possess distinct disadvantages. Because the bomb is made of 1 piece, it is impossible for the acids produced by the combustion to be in contact with anything but the bomb's inner surface. Illium, platinum, and gold are the only materials universally recognized as suitable for calorimeter bomb construction, and the former is to be preferred, since its solid construction eliminates all material which might be attacked by the acid, thereby destroying the accuracy of the bomb.

The bomb cover, too, is made of Illium, as is the fuel capsule held within the bomb. At the center of the cover is a valve, also of Illium, by which means the compressed oxygen is admitted to the bomb. The valve is so constructed that the gas is entrapped within the bomb until it is desired to remove it after completing a determination, when a slight pressure on the valve opens it, and permits the gas to escape.

The cover is held on the bomb by means of a steel screw cap, sufficiently strong to withstand the pressures developed during combustion.

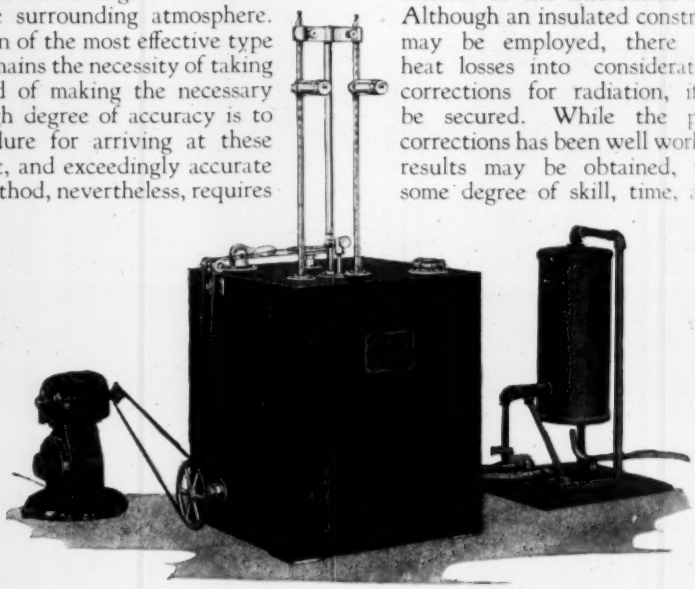
As normally, operated, the charge is carefully weighed, after which it is placed in the fuel capsule, the fuse wire is attached to the bomb cover and looped so that it will touch the charge, and the cover is then placed in position and tightened down by means of the screw cap. Oxygen from a cylinder is then introduced through the valve in the cover, after which the bomb is placed within the water container, in which has been poured a carefully measured volume of water. This water is uniformly circulated by a stirring mechanism to insure uniformity of temperature, which is noted by a special calorimetric thermometer placed in the water and extending through the top of the calorimeter. In the standard type instrument, the gradual change in water temperature immediately before, and immediately after a determination, must be noted, from which is calculated the correction for radiation. After noting the gradual temperature change, the charge is then ignited by means of an electrical circuit through the fuse wire. Readings of the thermometer are taken every half minute until the maximum temperature rise is determined, after which the final radiation correction is determined by another series of thermometer readings. The gas is then drawn from the bomb, the bomb is opened, and the acids formed are collected for titration. Since there is a known heat of formation of these acids, it is necessary to determine the amounts present in order to make the proper correction. It is here that Illium plays such an important part, for if the acid should attack the bomb, errors would result from (1) improper

acid determinations in the titration, (2) improper heat formation because of the acid's attack on the bomb, and (3) improper water equivalent of the bomb because of its change in weight. The Illium bomb entirely eliminates the possibilities of these errors.

The heating value of the substance is determined by noting the temperature rise of the water, and by making the proper corrections for (1) fuse wire, (2) radiation, (3) thermometer corrections, (4) acid titration, and (5) sulphur content. From this data, and from knowledge of the quantity of water used, and the water equivalent of the metal parts of the calorimeter, the heating value is readily computed.

The calorimeter jacket is constructed of 2 cylinders of laminated bakelite, between which is a dead air space which effectively limits the radiation. The bottom of the jacket, as well as the cover, is also made of 2 pieces of bakelite which enclose an air space. The jacket cover is firmly held in place by means of 2 spring clips. Power for the stirring mechanism is supplied through a pulley above the cover, which is rotated at a uniform speed by means of a small electric motor. The thermometer supplied with the instrument is made from thoroughly annealed glass, and has the manufacturer's certificate of accuracy and a correction chart showing what small variations from perfect accuracy may exist. The use of this special thermometer is of great importance in calorimetry, as an error in the readings of the thermometer are multiplied several hundred times in arriving at the final calorific value.

Oxygen Bomb Calorimeter, Adiabatic Type. In calorimeters of the usual type having jacketing walls of bakelite or other insulating material, there is a heat interchange between the interior of the instrument and the surrounding atmosphere. Although an insulated construction of the most effective type may be employed, there yet remains the necessity of taking heat losses into consideration and of making the necessary corrections for radiation, if a high degree of accuracy is to be secured. While the procedure for arriving at these corrections has been well worked out, and exceedingly accurate results may be obtained, the method, nevertheless, requires some degree of skill, time, and



care in manipulation. Therefore, the advantages can readily be appreciated in an instrument so constructed as to secure adiabatic conditions within the

apparatus, thus avoiding heat leakage and the consequent necessity of corrections.

The interior of the instrument, or calorimeter proper, is similar to the Standard Type Burgess-Parr Oxygen Bomb Calorimeter, and is completely surrounded by jacketing walls through which water is circulated under close control of temperature. Therefore, by maintaining the jacket at a temperature corresponding with that of the interior of the instrument, all heat losses due to radiation are eliminated. The water container, which holds the bomb, is located within a casing, so fitted to allow a minimum of air space between them. Surrounding the casing is the jacket into which a thermometer extends, and through which water is circulated. An exact temperature control of this water is obtained by means of hot and cold water inlets located at one side of the calorimeter. By means of a rotary pump, which also includes a horizontal stirrer, a portion of the jacketing water is directed upward into the cover, through which it flows, thence returning to the jacket. Circulation is very rapid; consequently, in the equalization of temperatures, the effect of lag is reduced to a minimum.

In opening the calorimeter, the entire cover is lifted slightly by a cam with lever attached, after which it is swung to one side. A locking rod is provided which makes it impossible to swing the cover until the thermometers are lifted free from the main body, thus insuring them from breakage. In lifting the cover, the driving pulley, which operates the stirrer in the water container, is automatically disconnected from the driving shaft. The temperature regulation by means of hot and cold water inlets results in an excess of water which automatically drains through outlets.

The jacket is made of laminated bakelite, molded into a box form, and having a highly polished black surface exposed. The metal parts (except the Illium) are heavily plated.

This type of calorimeter employs the same Illium bomb used in the Standard Type, and thus provides every advantage which might be desired in a calorimeter.

It is particularly well adapted for use in a chemical laboratory in which there is a regular routine of this type of work. Not only does the adiabatic feature save time by the elimination of the radiation correction factors, but it increases the accuracy by eliminating otherwise necessary calculations. It is built so the inexperienced operator can readily acquire the technique necessary for exact work; and for the trained chemist, it offers a simpler, more rapid, and equally exact method for determining calorific values.

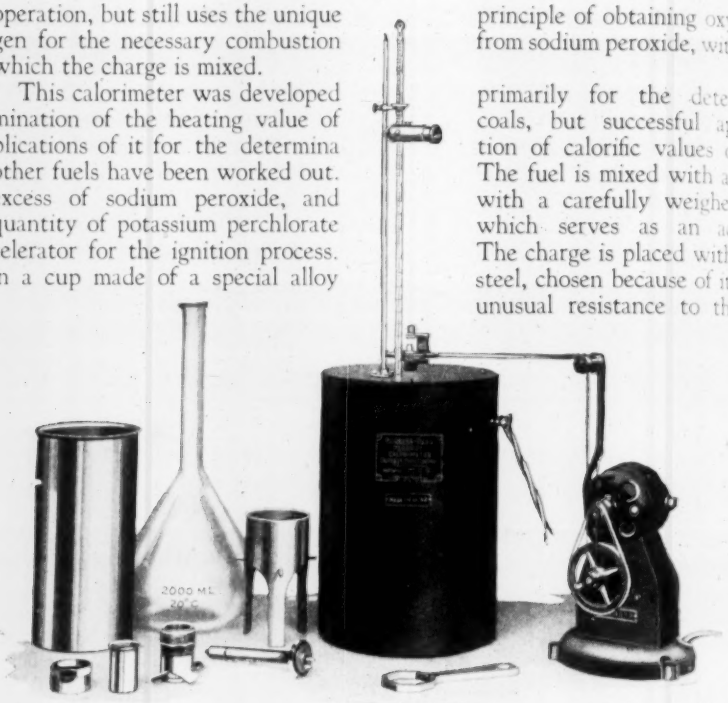
The Burgess-Parr Peroxide Calorimeter

(Burgess Parr Company)

THE Burgess-Parr Peroxide Calorimeter is the present commercial development of the original Parr Calorimeter which was first marketed by the Standard Calorimeter Company in 1899. Since then it has, of course, undergone radical changes in design and has been improved in its

operation, but still uses the unique principle of obtaining oxy- gen for the necessary combustion from sodium peroxide, with which the charge is mixed.

This calorimeter was developed primarily for the deter- mination of the heating value of coals, but successful ap- plications of it for the determina tion of calorific values of other fuels have been worked out. The fuel is mixed with an excess of sodium peroxide, and with a carefully weighed quantity of potassium perchlorate which serves as an ac- celerator for the ignition process. The charge is placed with in a cup made of a special alloy steel, chosen because of its unusual resistance to the



alkaline fusion resulting from the combustion process. The cover with ignition wire attached is located and the bomb tightly sealed by a screw cap. The use of soft lead gaskets between the cover and "fusion" cup is recom- mended, as their use insures a tight seal, at the same time eliminating the chance for organic material to be present to react with the fused peroxide. Stirring fins are attached to the bomb, which is then placed upon a pivot within the water container. During the combustion process, the entire bomb is revolved by means of an electric motor, thereby eliminating the necessity of a separate stirrer. Readings to determine the radiation factors are made, after which the charge is electrically ignited, and the temperature rise noted in the usual manner.

The usual correction factors for radiation, burning of the ignition wire, etc., together with the special corrections for the accelerator, hydration of the sample, etc. are applied to the readings noted. From this, the calorific value of the fuel can be readily calculated.

Because of the excess of oxygen present in the sodium peroxide, the re- sultant products are completely oxidized. All of the sulphur present becomes SO_3, and all of the carbon, CO_2. These in turn combine with the sodium salts to form sodium sulphate and sodium carbonate, respectively. Because of this complete oxidation it is a relatively simple matter to deter- mine both the sulphur and carbon contents of the original sample from the fused material. Accessory apparatus, namely the Burgess-Parr Sulphur Photometer and Burgess-Parr Total Carbon Apparatus, are used extensively to assist in making these determinations.

The advantages presented by the Burgess-Parr Peroxide Calorimeter are as follows:

(1). The original investment is low.

(2). The calorimeter is portable, as there is no need for the usual bulky oxygen cylinder.

(3). Its operation is simple, and the instrument can be used successfully by those not especially skilled in chemical analysis. This is of particular importance for industrial control work.

(4). The resultant fusion from a calorimetric determination provides an excellent basis for the determination of sulphur and total carbon in the original sample. The calorimeter can, of course, be used for this purpose alone if the calorific value of the fuel is not required.

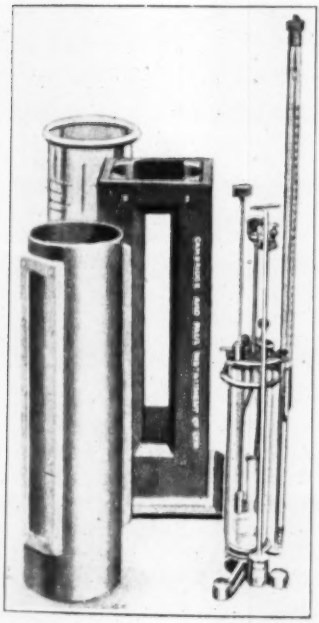
(5). The calorimeter is guaranteed accurate within 0.5%. It is carefully made, all parts being machined to exact weights so that the water equivalent of the metal parts is constant.

The use of this type calorimeter requires a careful control of the chemicals needed. Both the sodium peroxide and potassium perchlorate must be of the highest purity, and must pass certain physical standardizations as well.

In this instrument, as well as in other types of calorimeters, the thermometers used must be thoroughly dependable. To maintain their original accuracy, they must be made of glass which is thoroughly annealed before the thermometer is calibrated. The thermometers supplied with Burgess-Parr Calorimeters are put through an annealing process which requires several months, and are made to rigid specifications.

The Rosenhain Fuel Calorimeter

(Cambridge Instrument Co., Inc.)



THE Rosenhain Calorimeter which is a simple instrument for the determination of the calorific value of coal and liquid fuel, works on the well-known Thomson principle, a sample of coal, or an absorption pellet soaked with the oil under test, being burned in a closed vessel under water. The novel design and arrangement of the Calorimeter vessel and the combustion chamber render this operation easy, rapid and certain; the design also secures that all the heat generated by the combustion shall be directly communicated to the water of the calorimeter.

Construction of the instrument. The instrument consists essentially of 2 parts, the calorimeter vessel containing the water, and the combustion chamber in which the coal sample is burned. The combustion chamber is formed of a glass lamp chimney, closed at the top and bottom by nickel-plated brass

clamping plates which are separated from the glass by rubber washers.

The plates are drawn together by means of screws on three nickel-plated brass uprights fixed to the lower plate. A ball containing a stuffing box is mounted on the upper plate through which a tube passes carrying the electric ignition device.

The upper plate also carries a tube for admitting oxygen into the combustion chamber. A wire-gauze nozzle is fitted to the end of this tube to prevent the oxygen jet from breaking up the coal sample.

The combustion chamber communicates with the exterior by means of an aperture, thus permitting the products of combustion to pass from the vessel to the surrounding water. This aperture is closed by a ball valve which allows the gases to pass from the combustion chamber to the surrounding water, but prevents the water entering the chamber. An arrangement is fitted by means of which the ball can be raised and so allow some water to enter. This water is then forced out by the oxygen and mixed with the rest of the water, thus insuring that the calorimeter and its contents are brought to one temperature. To prevent radiation, the calorimeter vessel is enclosed in a wooden case, through openings in the sides of which the progress of combustion may be watched.

The advantages claimed for the Rosenhain Calorimeter are: Accuracy. Practically complete combustion is secured, less than $\frac{1}{2}\%$ of the sample escaping combustion. When combustion is properly regulated no carbon monoxide is formed. When burning oils the saturated pellets burn completely and rapidly, thus avoiding the risk of some of the oil remaining unburnt in the absorbent pellet. *Rapidity.* A determination of the calorific value can be made in little more than 30 minutes. The combustion of 2 gm of coal occupies about 10 minutes. *Safety.* No parts of the apparatus are exposed to high pressure, and the risk of breakage is small. *Low cost of experiment.* A small quantity only of oxygen is required, and the one breakable part is a glass chimney, which can be replaced by an incandescent gas-light chimney for little cost. *Ease of observation.* As the sample burns under observation, its behavior as regards caking and clinkering can be studied. *No stirring required.* The water is agitated by the gas bubbling through it.

The Scholes Bomb Calorimeter

(G. Cussons, Ltd.)

THE bomb body, cover and most of the details are made of stainless steel, and are machined from the solid billet. The bomb is inverted so that the cover forms the base on which it stands, and the ignition rods (one of which acts as a support for the crucible cradle) are attached to the base. The upper portion of the bomb is thus in one piece, the head of which carries the charging and discharging valves, and the complete bomb consists of 2 parts only, i. e., the body and the base. This design insures a rapid heat transmission through the head and upper walls of the body unimpeded by external attachments, such as heavy clamping nuts, and enables the stirrers to fit closely to the body of the bomb, thus causing an effective circulation of the water over the surface of the bomb.

Gas Pressure Seal. The bomb is sealed against the escape of oxygen or products of combustion by the use of a self-sealing rubber ring, Fig. 2. This ring fits in a chamber formed by a slight recess in the base and the under

face of the body of the bomb. The inner face of the bomb body projects downwards in the form of a spigot and so forms a chamber which is flooded with water (placed in the bomb to absorb any nitric or sulphuric acid fumes caused by combustion of the fuel) just before the bomb is charged with oxygen. This sealing ring is thus isolated from the combustion zone and cannot be damaged in any way. Since the sealing effect is produced by the pressure of the contained gas only, the two parts of the bomb, i. e., the body and the base, screw together by hand, and the use of large spanners, lead or similar metallic packing rings, and jigs for holding the bomb during the process of assembling, is avoided. The confidence and ease of operation obtained by this method of assembly facilitate the carrying-out of tests, and it will be found a distinct advance on other methods of sealing the bomb. At the end of a test the bomb is taken adrift by hand, and due to the method of assembling it is impossible to damage the threads or to create any wear even after prolonged periods of use.

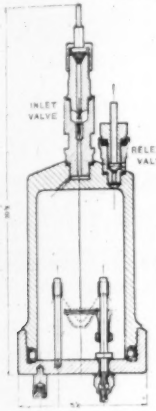


Fig. 1

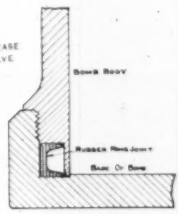


Fig. 2

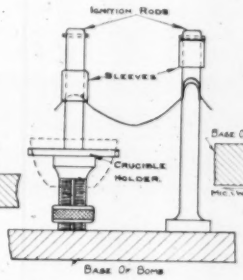


Fig. 3

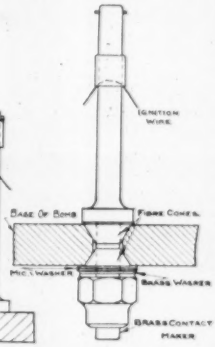


Fig. 4

Charging and Discharging Valve. The oxygen enters the bomb through a spring-loaded non-return valve, and is discharged through a screw-down valve. By this means the trouble experienced with screw-down inlet valves, which necessitates the provision of a gland and stuffing box, have been avoided. Steel or metal valves corrode and get dirty in use if required to pass the products of combustion from the bomb at the conclusion of tests. In the "Scholes" bomb the non-return inlet valve passes clean oxygen only, whilst the discharge valve is held in a separate fitting and does not require a stuffing box. Both valves are so arranged that they may be quickly taken out, if required.

Crucible Support. The crucible is held in a cradle attached to a sleeve which slides along and rotates about one of the ignition rods, Fig. 3. The sleeve carrying the cradle is split and any degree of tightness of the sleeve on the ignition rod may be obtained. Particular attention is directed to the method used of attaching the ignition wire to the ignition rods. The wire used is 0.004 in. diamter, and it is customary in other bombs to obtain the electrical connection to the ignition rods by wrapping the ignition wire round the rods. This is not a positive method, and as it is difficult to make good electrical connection, occasional ignition failures occur.

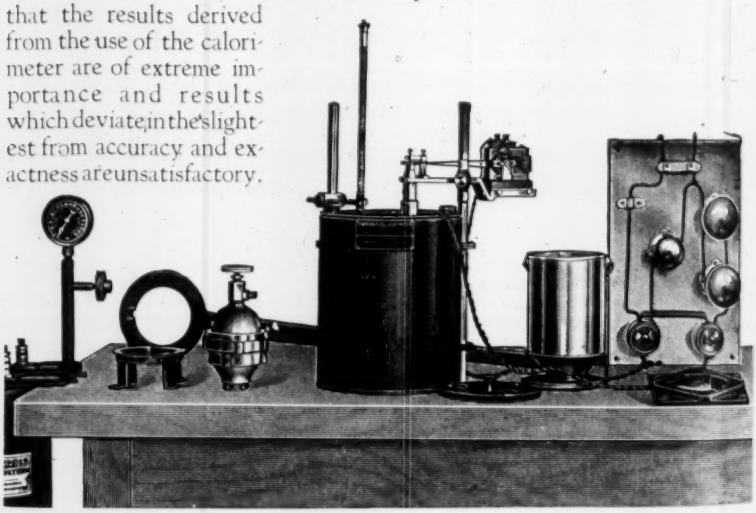
In the "Scholes" bomb the attachment of the ignition wire is simple and positive, and good electrical contact is assured. The ignition rods are slotted at an angle to the centre of the rods, and sleeves having chambered edges at their base are provided. One end of the ignition wire is placed in one of the slots, and trapped in that position by sliding the sleeve down over the wire. The wire is then led through the slot on the other rod and similarly trapped by the corresponding sleeve. By holding this sleeve and pulling the surplus wire smartly upwards, the chamfered edge of the sleeve acts as a wire cutter and there is thus no waste of the ignition wire. The electrical contact is positive and no cases of ignition failure should arise.

Ignition Arrangements. The ignition rods, made of 3/16" diameter stainless steel, are comparatively short and hence very rigid and strong. Both are attached to the base, one passing through it and being insulated from the metal of the base, Fig. 4. This insulated ignition rod terminates in a fitting carrying a spring-operated brass plunger, which makes electrical contact with the metal of the calorimeter vessel containing the measured amount of water. Examination of the diagram will show that the insulating packing used for this joint, where the rod passes through the base, is not exposed to the flame of combustion as is generally the case, since it is submerged in the water used for the absorption of the acid fumes. There is consequently no leakage at this joint and the joint is not subjected to heat.

The Emerson Calorimeter

*C. J. Emerson**

THE heat of combustion calorimeter for determining the calorific power of solid combustibles graduated from the research or experimental laboratory approximately 30 years ago, entered the industrial laboratory and since has progressively assumed more and more importance as an adjunct to efficient manufacturing. The elements of the calorimeter itself are simple but in endeavoring to perfect the apparatus and methods of operation of the same, countless effort has been expended. This is because of the fact that the results derived from the use of the calorimeter are of extreme importance and results which deviate in the slightest from accuracy and exactness are unsatisfactory.

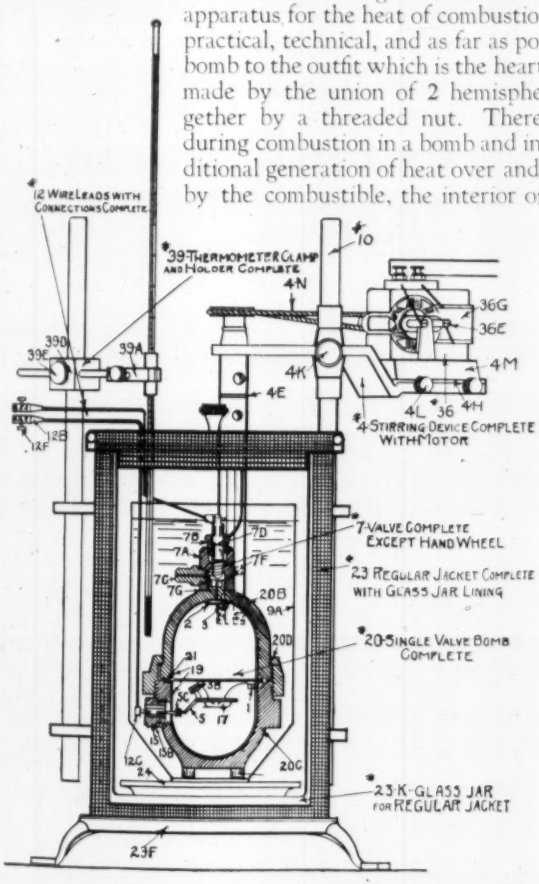


*Emerson Apparatus Company

There are several types of calorimeters for use with solid combustibles but the so-called bomb type is the most common. In this apparatus the combustible is burned in a strong receptacle called a bomb in the presence of an excess of oxygen under pressure. The bomb is totally immersed in a known amount of water during the combustion and the resulting rise in temperature of the water is measured accurately with a suitable standard thermometer. The rise in temperature of the calorimeter water is the measure of the calories given off by the complete combustion of the known weight of combustible in the bomb.

A demand for a calorimeter of the bomb type to be made in this country resulted in the birth of the Emerson calorimeter in 1908. Previous to this date, the greater part of bomb calorimeters in use in laboratories scattered about the country were imported from abroad although there were a few calorimeters of American make at that time. The calorimeters of foreign manufacture were rather expensive and repairs to these imported instruments were difficult to obtain and also costly. The American made calorimeters were satisfactory for the intended purpose but were in no cases manufactured on a sufficiently commercial scale to be available when needed by the customer.

The Emerson calorimeter was designed with the intention of making an apparatus for the heat of combustion test which would be practical, technical, and as far as possible, fool proof. The bomb to the outfit which is the heart of the apparatus was made by the union of 2 hemispherical cups joined together by a threaded nut. There are acids generated during combustion in a bomb and in order to prevent additional generation of heat over and above that given off by the combustible, the interior of the bomb should be acid proof or otherwise it is necessary to make a correction to offset the heat given out by the action of the acid on the interior wall of the bomb. The Emerson bomb is fitted with removable linings and the acid proof linings found to be most satisfactory are the gold rolled on silver sheet spun to closely fit the interior and the vitreosil linings which are the latest development in acid proof linings.



The bomb when under test, as above stated, is fully immersed in water in the calorimeter bucket and surrounding the whole is the calorimeter jacket. There have been many types of jacket developed which were mainly designed either to prevent radiation from the bucket or to establish fixed conditions between the bucket and its surroundings which would then permit accurate computation of the amount of the heat exchange between the two. The Emerson calorimeter jackets are of 3 designs. The regular jacket consists of a cylindrical glass jar as an inner lining carrying the bucket and surrounded with a lagging of felt, the whole being carried in a sheet metal container. The glass jar acts as an insulating wall and prevents loss of appreciable heat from the calorimeter proper. The vacuum walled calorimeter jacket is composed of a large size vacuum flask mounted in a felt lined container and the vacuum wall effectively prevents an exchange of heat between the calorimeter bucket and the side walls of the jacket. The Adiabatic type of jacket, in which radiation of heat from the calorimeter bucket is largely prevented by carrying the jacket water through the same rise in temperature as in the calorimeter, has been found satisfactory by many operators and the Emerson calorimeter uses the Daniels Adiabatic jacket for this purpose. The Daniels Adiabatic Jacket adds heat to the jacket water by passing an electric current directly through the jacket water it being necessary to use the alternating current type of circuit.

Water Jacketed Calorimeter*

(Gaertner Scientific Corp.)

SMALL Inner Vessel is 11.5 cm high, 7.5 cm in diameter and has a capacity of 500 cc. It is made of hard brass nickeled and polished on the outside. The wooden support supplied with it, is made sufficiently high so that the upper rim of the vessel comes closer to the cover of the water-jacket when it is placed inside.

Large Inner Vessel is made of hard rolled brass and is nickel-plated and polished on the outside. It is 20 cm high, 12.5 cm in diameter and has a capacity of 2½ liters. With it is supplied a wooden support for holding it clear from the bottom and walls of the water-jacket.

Water-Jacket is a double walled vessel of hard rolled brass, nickel-plated and polished inside and covered by a felt jacket 1.3 cm thick, which again is surrounded by a nickel-plated brass shield, and is attached to a transite base. The felt covering serves to protect the vessel from temperature changes, while the plated and polished inner surface helps to diminish the radiation correction of a calorimeter when surrounded by the jacket. The nickeled brass shield protects the felt and the base gives additional strength and insulation. The water-jacket is 25.4 cm high and 25.4 cm in diameter over all; the space between the inner and outer walls is 3.5 cm. Screw sockets are provided on top to attach the yoke of the apparatus for mechanical equivalent of heat, and a tubulure is provided for inserting a thermometer and also for filling the water space. A stopcock at the bottom serves to drain the inner vessel, when used as an air-jacketed ice bath in connection with the Bunsen Ice Calorimeter. The bottom, made of extra heavy material to prevent damage, is reinforced in the middle, by a solid piece of brass.

*For illustration see Page 25.

The large stirrer is made of a flat ring of sheet brass, turned down at the outer edge for stiffness, and has a brass handle long enough to pass through a hole in the cover of the water-jacket. The inner diameter of the ring is 6 cm, enabling large objects to be placed in the calorimeter without interfering with the stirrer.

Cover for the water-jacket is made of heavy transite, a strong insulating material similar to asbestos, and superior to the laminated wood formerly used. The transite cover is finished in durable dark green enamel. It is pierced by a central hole 5.1 cm in diameter and by smaller holes for the passage of thermometers, clamping screws, stirrer, handle, etc.

Roth Microcalorimeter

(Franz Hugershoff, G. m. b. H.)

HERETOFORE precision combustion bombs had a water equivalent of 2400-2800 gms, so that in order to obtain the usual temperature increase of 1.5° with a substance having a heat value of 5000 cal, 0.7-0.8 gm of the sample was required. To obtain a good determination about 2 gms were necessary. When determining the heat values of costly substances or where only small amounts of the sample is available, this is out of the question. The determination of the heat value in a calorimeter, though, is the only sure method for obtaining the data on organic materials.

Considerable experimentation has been carried out in order to devise a method of microanalysis. Previously to measure the small heat effects, the Bunsen Ice Calorimeter or a metal calorimeter with thermocouples was used. The Roth micro-bomb permits the measurement of the temperature increase of a water calorimeter by means of a Beckmann thermometer. It has a water equivalent of barely 600 gms, so that less material is required for 3 determinations than is usually required for one. Two models of the bomb are available: One is wholly constructed of V2A-Steel, the other is bronze with an acid resistant lining of silver. Both models are furnished in 3 parts. The various parts are so constructed that they go together easily, without forcing. The stirrer is driven electrically at 70 R. P. M. It is built so that it provides sufficient circulationbetween the feet and above the cover of the bomb. Constant stirring and the use of a reliable Beckmann Thermometer is essential. The reading should be taken at ½ minute intervals. The accuracy is approximately the same as with the larger apparatus*. The bomb is also suitable for the rapid determination of organic substances (carbon, hydrogen, sulphur, ash, or metals). Both models permit passing air through the bomb for the determination of vapor or gaseous combustion products.

*Zeitschrift fuer Elektrochemie, August 1924

Berthelot - Mahler - Kroeker Calorimeter*

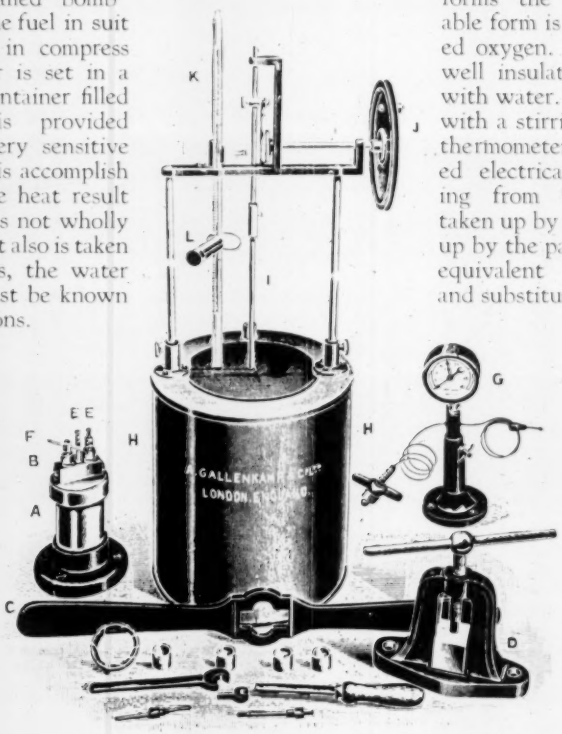
THE most generally recognized and reliable method for the determination of heating value of fuels is that first developed by Berthelot and Vieille.

*A. Gallenkamp & Co., Ltd.
Franz Hugershoff, G. m. b. H.
Julius Peters

Numerous investigators, Mahler,[1] W. Hempel,[2] Kroecker,[3] Kleber and Langbein,[4,5] Jacob[6], and others deserve considerable credit for the development of the process as well as the bombs, in which the combustion of the material in compressed oxygen takes place.

In principle the method is as follows: The so-called "bomb" forms the space in which the fuel in suitable form is tested by burning in compressed oxygen. The steel container is set in a well insulated calorimeter container filled with water. This container is provided with a stirring device and a very sensitive thermometer. The ignition is accomplished electrically.

As the heat resulting from the combustion is not wholly taken up by the water but a part also is taken up by the parts of the apparatus, the water equivalent of these parts must be known and substituted in the calculations.



The weight of the water in the bomb and in the calorimeter, plus the water equivalent, multiplied by the corrected temperature increase of the calorimeter water gives the combustion heat of the fuel, after correcting for cooling, ignition and nitric acid.

The bomb is made of steel with its inner surface covered with platinum or enamel. More recently the bomb has been made of acid-resistant Krupp V2A steel. The lid is screwed on firmly. Through the lid pass the entrance and exit gas channels for the introduction of oxygen and for the exit of the combustion gases. To prevent leakage a lead gasket is used between the lid and the body. The platinum wire pole passes through the center of the lid. The ignition wire is wound around the platinum tube and the platinum wire pole.

[1]Zeitschrift fuer angewandte Chemie, Vol. 5. (1892) page 491.
[2]Zeitschrift fuer angewandte Chemie, Vol. 5. (1892) page 389; Vol. 9. (1896) page 350.
[3]Zeitschrift fuer angewandte Chemie, Vol. 9. (1896) page 327; Vol. 10 (1897 page 327; Vol. 11 (1898) page 565. Vol. 14 (1901) page 444.
[4]Journal fuer praktische chemie, Vol. 39 (1889) page 518.
[5]Zeitschrift fuer angewandte chemie, Vol. 13 (1900) page 1227, 1259.
[6]Zeitschrift fuer chemische Apparat kunde, Vol. 2 (1907) pages 281, 313, 337, 369, 499, 533, 565, 597.

The wire is brought to glowing by means of an electric current, as soon as the wire melts the current is interrupted and no more heat is added.

During the combustion the bomb is placed in a nickel plated or nickel sheet container, the calorimeter, filled with water. To protect the container from the influence of the surroundings and to protect against radiation it is placed in a second empty, brass cylinder and this again placed in a large double walled copper container, filled with water.

The cover of the calorimeter is made of ebonite, through which passes a stirring device which moves up and down about once a minute. A sensitive thermometer is also placed in the container.

Below are described B. t. u. Indicators.

Ott-Lux-Gas-Tester

(Alpha-Lux Co., Inc.)

OTT-LUX-GAS-TESTER is simple in construction and operation. It combines in one operation the information usually obtained by 3 distinct time absorbing manipulations, namely, the Gas Analysis, Specific Gravity determination and Calorimeter test. While it is true that it cannot replace any of the 3 tests where specific results are required, it is equally true that it will show any changes in the gas, which are caused by changes in composition, gravity or heating value.

To make these 3 tests requires hours. By this simple piece of apparatus the collective information can be obtained in the fraction of a minute.

The apparatus consists of a Bunsen type burner to which a simple mechanism is added to accurately regulate the primary air. A pointer is used to operate the air shutter. This pointer rests on a graduate disk sub-divided into 100 equal parts.

When the pointer is at zero no primary air is supplied to the burner. By turning the pointer clock-wise we gradually admit air and this is continued until the flame becomes so sharp that it almost flashes back, which is indicated by a series of small explosions and jumping of the flame.

It is true that the figure at the disk to which the pointer points at this moment is purely an empirical one, but after determining this point with a gas of standard quality, the gas maker or any other person can, without losing much time, readily determine if the quality of the gas is changing and in which direction.

With a little practice he can also determine how much the gas has deviated from normal.

The pressure of the gas is regulated by means of a cock placed in front of the pressure gauge. To operate the tester, the pointer is placed at 0 and the gas lighted. The gas cock is then regulated so that the pressure gage indicates 40 mm pressure and the pointer turned until the flame sputters as described above. This is first done with a sample of gas which is known to be standard and of which not only the heating value is known but also the gravity and composition.

If during the course of operation it becomes necessary to move the pointer farther from zero than the point originally established with the known quality of gas the heating value increased since it requires more primary air. On the other hand, if the pointer must be turned back towards zero, the gravity changed, permitting less gas to pass the orifice, which means a

change in composition, most often caused by increased amounts of inerts, at any rate a decrease in heating value.

The Lanphier Caloroptic

(Rossiter & Co., Inc.)

THE Lanphier Caloroptic is the result of years of chemical research and gas investigation of the late Charles H. Lanphier. All the variables entering into recording the combustion of gases in the caloroptic have been reduced to that of merely the control of the amount of air required to burn the gas.

It is constructed so that a micrometer barrel admits the air to burn the gas and at the same time reads the heating value of the gas. The point of complete combustion, that is when the yellow tip disappears upon running the micrometer barrel up,—is the point at which to read the heating value of the gas direct in B. t. u. per cubic foot.

The Caloroptic is calibrated against a standard gas calorimeter by adjusting the screw in the base until the wet calorimeter and the Caloroptic read the same.

The Caloroptic is 8½" high and measures 4" across the base. The burner is very rugged and stands rough gas house use without any effect on its accuracy. It meets the requirements of the water gas maker, the coal gas maker, the mixed gas send-out pressure man, the plant superintendent, the company manager and the company president. In many cases it has enabled the retort house foreman to increase yields and the water gas foreman to save oil. It is valuable because anyone can instantly tell very closely the B. t. u. of the gas he is making without having expert knowledge of calorimetry.

Gas makers like it because if the gas runs richer than it should the yellow tip will appear and if the gas runs lean they can tell it by the noise of the inner green cone. It has been used to advantages on service complaints, it tells instantly when there is a low B. t. u. spot and where non-flow or dead end spots exist.

The Caloroptic is intended to be used on the gas with which it is calibrated, but does not register higher than 900 B. t. u. A great many tests, however, show that it is very accurate (½ of 1%) on many kinds and various proportions of different gases.

The Brady B. T. U. Indicator**

*R. A. Malony.**

THE indicator filled the long-felt need for a method of obtaining a quick B. t. u. reading, which could be made by a person having no technical experience. A complete determination of the heating value of the gas can be made with it in 2 minutes. This, together with the fact that it is port-

*Physical Laboratory, The U. G. I. Contracting Company.
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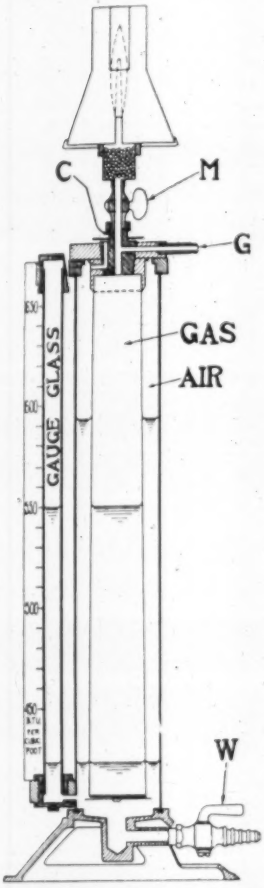


able and does not require a source of running water with an overhead tank, as is the case with a flow calorimeter, probably led to the present popularity of the instrument.

The principle of this instrument is based on the fact that a simple relation exists between the total heating value of a gas and the amount of air necessary to form the well defined blue inner cone of a Bunsen burner flame. This principle is utilized in the Brady B. t. u. Indicator by causing the gas-air ratio to gradually change and pass through the point at which the inner blue cone becomes well defined. The change in the gas-air volume is brought about by rising water observable through the gage glass and it is not necessary for the operator to know these volumes. These volumes are taken into consideration in the calibration of the instrument, and from the principle involved the ratio of the gas and air volumes may be plotted to read directly in B. t. u. per cubic foot. The readings are independent of room temperature, humidity of the atmosphere and barometric pressure. The many other corrections necessary to apply to the standard flow calorimeter readings are also unnecessary rendering the instrument much less liable to the personal errors of the operator.

From the diagram, it is seen that the indicator consists essentially of a vertical brass cylinder 3″ in diameter and 17″ long, to which is attached a base and top casting. There is a slightly tapering cone of thin metal screwed into the top casting and concentric with the outside brass tube. This cone forms the gas chamber, and the annular space between it and the outside brass cylinder forms the air chamber. Attached to the side of the instrument is a gage glass for observing the height of the water in the gas space during filling, and the height of the water when the determination is completed, which height gives the gas-air ratio at that point, or, as explained above, gives approximate heating value of the gas on the attached scale. The air and gas are admitted, and the two chambers connected and separated by the main cock at the top.

Operation of B. t. u. Indicator. The air from the room and the gas to be tested are drawn into the instrument by the lowering of the water level, and expelled by the raising of the water level. The aspirator attached by a hose to the indicator, furnishes the means of changing the water level. The gas is drawn into the center cone, and the air drawn into the outer space simultaneously. The pressure of the gas in the instrument is then reduced to atmospheric by allowing the excess gas to escape. The air and gas, being at the same pressure, are connected at the top and expelled as an air and gas mixture through the mixing chamber to the burner, where the mixture is ignited.

The water as it ascends is at the same level in both air and the gas chambers, and can be seen in the gage glass. As the gas cone is lightly tapered, the gas percentage in the mixture is constantly decreasing, and the air percentage constantly increasing. This produces a change in the resulting flame. The luminosity gradually decreases, and the outline of the blue inner cone begins to form. At the instant the tip of the inner cone forms a definite line the water is shut off at cock "W" and the approximate heating value read on the scale opposite to the stationary height of the water in the gage glass.

Below are described Steam Calorimeters.

Carpenter Steam Calorimeters

(Central Scientific Company)

THE available energy in steam varies greatly with the quantity of water which it is carrying at any given temperature. Actual working conditions, or the efficiency of any steam plant cannot be known without frequent accurate determinations of the water content in the steam. The Carpenter Calorimeters are the first small convenient instruments devised for this purpose which give rapid measurements with accuracies within one-half of one per cent without requiring any special skill or training on the part of the operator.

There are two forms of the Carpenter Steam Calorimeter, separating and throttling the former designed to separate and measure the water carried by a measured quantity of steam, and the latter determining the quantity of energy required to evaporate the moisture which the steam carries. The two instruments have practically the same application except that the throttling calorimeter is limited to the measurement of steams with moisture contents between 3.5% at 80 pounds absolute pressure and 6.2% at 250 pounds absolute pressure. These limits, however, cover practically any steam conditions found in most plants. The separating calorimeter is effective within the usual limits and in addition gives an accurate measure of exceptionally high or low moisture with no theoretical limit to the range of measurements possible.

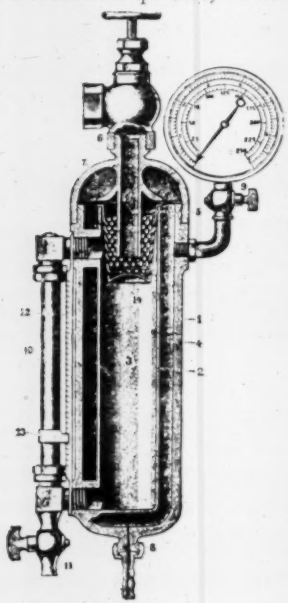


Fig. 1

The Separating Calorimeter is shown in detail in Fig. 1, and consists of two concentric vessels (1) and (2), the inner of which communicates with a glass tube water gage (10), and the outer with dial gage (9) for showing steam pressure and flow through the orifice (8). The outer scale is calibrated by trial with reference to the orifice to read directly pounds of dry steam leaving the calorimeter in ten minutes.

Steam enters through a globe valve (6) and is led downward through tube (5) to the separating cup (14), in which the course of the wet steam is changed sharply through an angle approximately 180°, throwing the water out through the fins of the cup by its greater inertia. The water thus separated collects in chamber (3) and is measured in the gage tube by the scale (12), graduated to read pounds by hundredths of water at a mean pressure of 100 pounds and temperature at 100°C. Errors resulting from using this scale, with variable temperature and pressures above and below 100 pounds and 100°C., are so small as to be negligible for practical purposes.

In use the calorimeter should be attached to a vertical pipe in the main steam line in which there is an ascending column of steam. The steam should not be drawn from a point closely adjacent to the pipe wall, and the instrument and connections, with the exception of the gages, should be wrapped with hair felt to prevent loss of heat by radiation.

In making an observation the globe valve is opened, allowing steam to blow through the instrument until it is well heated, after which a reading of initial water level is made on the glass tube gage. The average position of the indicator on the dial gage is then watched over a period of ten minutes, controlling the steam flow slightly through the globe valve if necessary to maintain a fairly contant reading. At the end of ten minutes, the water level in the glass gage is read on the scale, the initial reading of this gage substracted from the final reading, and the water content of the steam computed as follows:

W = pounds of water collected in ten minutes as read on gage (12).

S = pounds of dry steam passing the orifice in 10 minutes as indicated by the outer scale on the dial gage.

Q = W + S = total weight of wet steam analyzed.

% water = W/Q x 100.

The Throttling Calorimeter. A diagramatic cross-sectional view of the Throttling Calorimeter shows the proper installation. The calorimeter as supplied consists of a metal cup with steam outlet at the bottom, and tapped on opposite sides near the top to take a globe inlet valve and a mercury manometer. The top of this cup is deeply depressed in the center to form a well for a thermometer showing the temperature of steam flowing through the calorimeter. The calorimeter cup itself is about 3 inches in diameter. The inlet from the globe valve is in the form of a converging orifice, and a sampling tube is also supplied for drawing steam from a main stea line. The installation of this tube as in the case of the Separating Calorimeter, should be made in a main vertical pipe with an ascending column of steam. A mercury manometer is supplied, connecting with the calorimeter through rubber pressure tubing and a brass cock.

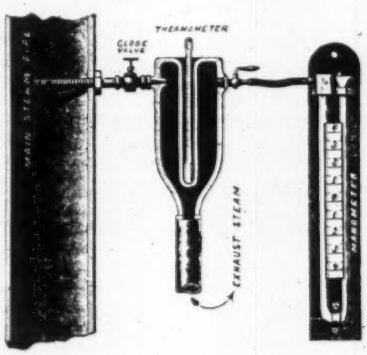


Fig. 2

The principle on which the Throttling Calorimeter operates is based on the so-called univariant nature of an enclosed system consisting of steam and water. Such a system under a given absolute pressure assumes a

corresponding fixed temperature and consequently has a definite energy quantity per pound of steam at any given pressure. If the pressure of wet steam be reduced without allowing the steam to do work in its expansion other than that of increasing its own volume, a certain quantity of energy is liberated equal to the difference in its energy values at the first and second pressures respectively. This condition exists, for all practical purposes, when wet steam escapes from the line into a small vessel at atmospheric pressure, such as the calorimeter cup; and in such a case, a part or all of the liberated energy is absorbed by the mechanically held water as vaporization heat, transforming the water to steam. If the quantity of water carried by the steam is such that its total vaporization heat is equal to or greater than the energy resulting from the decrease in pressure, all this freed energy will be absorbed as latent heat of steam, and will not produce a temperature rise in the expanding steam. If, however, the quantity of water be less than this amount, that fraction of the freed energy remaining after all the water is vaporized will effect an increase in the steam temperature above its boiling point, the actual temperature reached depending upon the quantity of steam and its specific heat at the final pressure. In this case the percentage of water carried by the steam at its original pressure can easily be calculated by the use of the following quantities: (1) the initial pressure, read from a gage on boiler or steam line; (2) the energy per pound of steam corresponding to the initial pressure, read from steam tables; (3) the final pressure after expansion, assumed to be atmospheric in most cases and corrected by manometer reading; (4) the energy per pound of steam at the final pressure, read from steam tables; (5) the final temperature as shown by the thermometer in the calorimeter cup, and (6) the boiling point of water at the final pressure as found from barometric tables.

Then using the value 0.47 as the specific heat of dry steam at atmospheric pressure, the percent of moisture carried by the steam at boiler pressure is given by the formula:

$$\% \text{ water} = \frac{H - h - 0.47\,(t - bp) \times 100}{L}$$

Where:
L = heat of vaporization of water at boiler pressure
H = total energy per lb. of steam at boiler pressure
h = total energy per lb. of steam at calorimeter pressure
t = temperature in calorimeter
bp = boiling point of water at calorimeter pressure

Steam Separating and Wiredrawing Calorimeter.

(Dobbie McInnes & Clyde, Ltd.)

PRINCIPLE. The "DOBBIE McINNES" Steam Calorimeter is a combination of a Separating Calorimeter which mechanically separates the moisture and a Throttling Calorimeter which superheats the steam by allowing it to pass through a small orifice.

The Separating Calorimeter causes the moisture to cling to the walls of the Chamber and to trickle down to the bottom where it accumulates and

is drawn off and weighed, any steam passing through being condensed and weighed.

The Throttling Calorimeter into which steam passes after leaving the Separating Calorimeter throttles the steam nearly to atmospheric pressure, the difference between the total heat on each side of the orifice being employed to convert the mechanically suspended globules of water into steam. The initial condition of the steam determines whether the heat set free superheats the steam or merely converts the moisture into steam.

The combination of these two calorimeters may be split up and used separately as a Separating or Throttling Calorimeter as desired, but it should be noted that the Throttling Calorimeter alone is not suitable for very wet steam as it is essential that the heat set free during throttling must be sufficient to convert all the moisture present into steam.

When using the Separating Calorimeter with a condenser, the "Dryness Friction" of the steam:

$$X = \frac{W_1}{W_1 + W_2}$$

Where W_1 = Weight of Condensed Steam representing weight of dry steam.

and W_2 = Weight of Water in Separating Chamber representing weight of moisture.

With the Throttling Calorimeter, the "Dryness Friction" of the steam:

$$X = \frac{H_2 + .48\,(t_1 - t_2) - h}{L}$$

where t_1 = reading of thermometer F_1;

t_2 = temperature of saturated steam after expansion (obtained from manometer reading and steam tables);

H_2 = total heat per lb. saturated steam corresponding to t_2;

h = sensible heat per lb. corresponding to temperature observed at F;

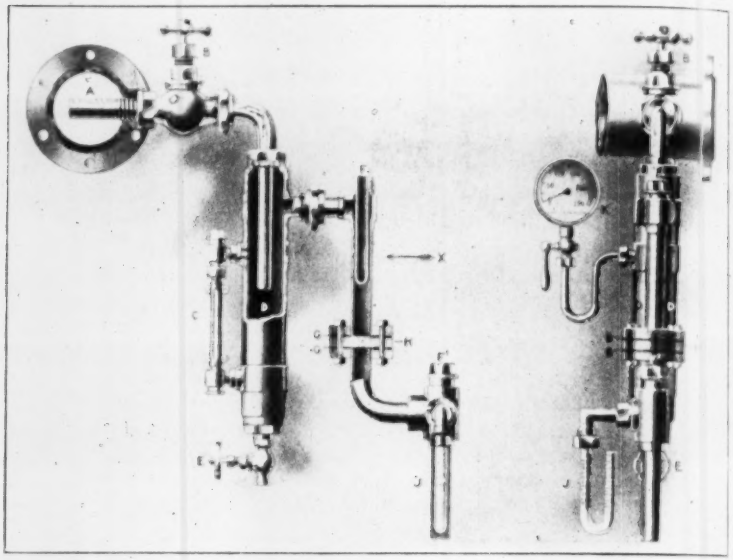
L = latent heat per lb. corresponding to temperature for wet steam before expansion observed at F.

0.48 = specific heat of steam assumed constant.

When both Calorimeters are in use together, the amounts of priming moisture obtained are added.

CONSTRUCTION. A *Valve B* having a special *Nozzle A* which is supplied in 3 lengths, is screwed into the steam pipe from which steam is to be drawn. After passing the valve, steam is led through a tube to the *Separating Chamber D* into which the tube projects as shown. A *Steam Pressure Gage K*, a *Water Level Gage C*, and a *Cock E* for drawing off the accumulated water are fitted to the Separating Chamber.

Steam, from which a large proportion of moisture has been removed, leaves the Separating Chamber near the top and enters the *Throttling Chamber* in which there is a *Plate H* having a fine hole for the wire-drawing process. Thermometers are placed in *Pockets F and F*[1] to measure the steam temperature before and after throttling, and a *Manometer J* is fitted on the exhaust side of the Chamber to measure the exhaust steam pressure.



A.—Inlet from Steam Pipe.
B.—Straight Full-Way Valve.
C.—Water Gage.
D.—Separating Chamber.
E.—Cock for Discharging Water.
F, F1.—Receptacles for Thermometers.
G, G—Vulcanite or Asbestos Packing.
H.—Plate for Wire Drawing.
J.—U-Tube to Register Exhaust Pressure.
K.—Gage to Register Steam Pressure.

The instrument is highly polished and plated to minimise condensation which is sufficient if the Calorimeter is guarded from draughts. It is recommended that a further precaution of lagging should be adopted.

ADVANTAGES:

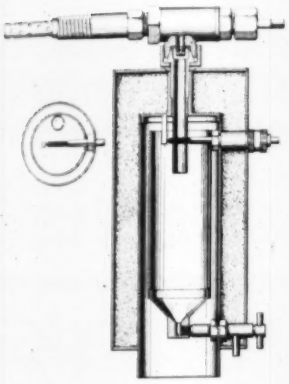
Great accuracy.
Ease of manipulation.
Possibility of employing either or both components of instrument according to circumstances.
Use on any steam pipes of any diameter.
Large range of application.

U Path Steam Calorimeter

(Lewis M. Ellison)

RECOGNIZING the necessity of minimizing radiation losses in steam calorimeters, Lewis M. Ellison, for more than 30 years has made extensive research in steam calorimeters and has given serious study to the subject of proper insulation as well as to other details necessary for the most efficient general design for instruments of this class. The first Ellison Throttling Calorimeter of the down-flow type was designed in 1902 and was insulated by means of a bright nickel plated casing, retaining around the steam chamber one-half inch lamp black, one of the best non-conductors of heat for this purpose.

Subsequently, finding that moisture escapes unaccounted for in down-flow throttling calorimeters, especially when the temperature of the superheat in the instrument approaches 212°F., this type was replaced in 1908



with the first Ellison U path steam calorimeter, utilizing the same insulating medium as in the down-flow instrument, widely known as the Ellison Throttling Evaporating Calorimeter.

With the advent of higher temperatures and lower percentages of moisture, more efficient adiabatic construction in calorimeters was essential. In December 1925, the new Ellison U Path Steam Calorimeter was designed to meet the extremely exacting technical requirements for determining the comparative quality of steam in two different makes of steam purifiers in boilers operating under 350 pounds pressure in a central station power house. In the improved instrument was added a steam jacket and the heat of conduction from the steam chamber was eliminated, resulting in a calorimeter giving the closest approach to theoretical temperatures ever recorded in steam calorimetry.

After entering the sampling pipe, the steam in this improved U path instrument flows horizontally with no up-turns to the throttling plug, in the orifice of which it is reduced to atmospheric pressure. Immediately below the orifice steam impinges against a plane surface where is is divided into four automized streams, meeting again and mixing below the plug. The throttled steam in the steam chamber flows in a U path, down one side and up the other, escaping at the top, where it turns and flows downward through the steam jacket and out at the bottom to the atmosphere. A momentary abnormal moisture content in excess of the throttling process is separated in the steam chamber and is re-evaporated by the superheated steam after the period of excess, giving a true mean superheat temperature at the calorimeter thermometer. The instrument thus forms a combined throttling, separating, and re-evaporating calorimeter in a single chamber, utilizing the U path of superheated steam which is the most efficient known method of calorimeter moisture evaporation.

The importance of insulation is given special attention in the design of this calorimeter. The jacket steam surrounding the steam chamber is kept at the same temperature as the steam in the chamber by insulation of the steam jacket against chilling. This is effectively accomplished by providing a 1″ insulating jacket on the sides and 1½″ jacket on the top of the steam jacket, both of which spaces are packed with lamp black. All radiation losses are minimized by the compact design of this calorimeter and further heat retention is insured by the brass insulation casing being highly polished and nickel plated. This arrangement of steam jacket, insulation jacket, and bright exterior surface provide in one instrument the three best known methods of reducing calorimeter radiation losses.

The exhaust tube, 3 x 10½″, connects telescopically with the steam jacket, carrying away the escaping steam, and insulates the steam outlet against the possibility of chilling.

Instead of a thermometer well, the thermometer is held in a packing cup. The holder terminates in the steam jacket, thus preventing heat of conduction from the steam chamber by the thermometer and holder.

The drain is located in the steam outlet, not conducting heat from the steam chamber.

The valve, designed for compactness, has a safe working pressure of not less than 1,000 pounds per square inch. The disc and seat are of Monel metal.

Instead of the conventional hand wheel, the valve is operated with a removable socket wrench, thus eliminating the radiation of the hand wheel and facilitates covering the entire stem. The valve body and stem, union and steam pipe nipple, to be covered by the operator, about 2" of tissue paper being efficient.

The union, being on the chamber side of the throttling plug, is under only atmospheric pressure and is not subjected to leakage.

The steam pipe nipple is of bronze, 1/2" i.p.t., with 7/16" diameter steam passage, and is tapped in the end for holding the interchangeable sampling pipe tips.

The sampling pipe tips consist of a set of five 7/16" i.d., perforated in accordance with the A. S. M. E. code, for 2, 3, 4, 5, 6" pipes, beyond which length of tip no sample of steam can be expected with this form of sampling pipe.

The throttling plugs are of Monel metal, interchangeable for the various pressures, consisting of a set of four, 1/16, 3/32, 1/8, 5/32" orifices.

The thermometer is gas filled, reading up to 400°F, and is graduated for 2" immersion. It is inserted directly into the steam bath and is held in a packing cup.

Dimensions: The steam chamber is 2 1/4 x 6", steam jacket 3" o.d., casing 5 x 10".

The Mason Regulator Co., of Boston, Mass. announces the appointment of the O'Brien Equipment Co., 2726 Locust Blvd., St. Louis, Mo. as exclusive distributors in the Missouri territory.

Measurements

Industrial & Scientific

An Instruction Book for Engineers

DR. WALTER BLOCK

Eichungsdirektor der Provinz Ostpreussen

CHAPTER XIV CALORIMETERY

CALORIMETRIC measurements are, comparatively of little importance to the engineer in so far as they deal with the measurement of specific heats of substances. These may be passed over here and only that part of calorimetry discussed which is of greater importance to the engineer, namely, the determination of the heating value. First however, something should be said on the heat unit. As is known, the unit of heat is designated as the calorie and is defined as that quantity of heat which is required to raise 1 kg or 1 gm of water 1°C. It is self-evident that the respective units have a ratio of 1000:1. They are, therefore, often referred to as kilo-calorie and gram-calorie. Since exhaustive experiments have shown that the value of a calorie depends somewhat on the temperature of the water, it is defined as that heat quantity which increases the temperature of water by 1°C at 15°C, i. e. from 14.5°C to 15.5°C.

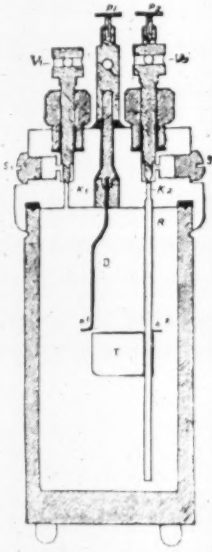


Fig. 81. Section through a calorimeter bomb.

The principal device for the determination of heat quantities, that is principally of the heat value of materials, is the calorimeter. In principle this is arranged so that a definite weighed amount of the substance is placed in a tightly closed container (Fig. 81) which is filled with compressed oxygen. The substance in the interior of the bomb is then ignited electrically from the outside, so that no gases can escape. An excess of oxygen is provided for the combustion. The heat liberated in this process heats the calorimeter and the water. The temperature rise of the calorimeter and water is measured, and from this the heating value of the substance placed in the calorimeter can be computed. In order to carry through this computation a constant of the calorimeter is needed which is extremely difficult to determine experimentally, namely the so-called water-equivalent of the calorimeter or the heat capacity of the material of the calorimeter as a whole. If the heat quantities developed by the combustion

Note: This chapter is a brief elementary description of some of the methods used in determining heating values of fuels. It is not complete enough to serve as a guide in determining heating values, especially in this country, where practice has been standardized much more perfectly than is called for in this text. Standard methods of sampling and testing coal and coke have been adopted and published by the A. S. T. M. and methods of gas calorimetry are described in detail in publications of the Bureau of Standards.

could be transmitted entirely to water the calories developed could easily be calculated from the amount of water and the measured temperature increase. Actually, though, a comparatively heavy metal container is heated at the same time which for better equalization of temperature is placed into a larger water bath. For the calculation of the developed temperature the masses and the specific heats of all individual parts of the bomb are required which is extremely difficult to determine, or the so-called water-equivalent which means that number that indicates the amount of water which would be equivalent to the whole mass of the calorimeter. For example, we will assume brass has a specific heat of 0.093. If we have 1 kg of brass, this would require a heat supply of 0.093 calorie to increase its temperature 1°C, i. e. for an increase of temperature, 1 kg of brass is equivalent to 0.093 kg of water, that is the water-equivalent of 1 kg brass is 93 gm. The specific heat for all individual parts of the calorimeter must be determined in order to be able to derive the total water equivalent. This is a such difficult task that it is practically never done. The calorimeter is generally calibrated with standard substances, i. e. substances of definite composition with accurately known combustion values are placed into the calorimeter, burned, all observations made, and then the water equivalent of the bomb and the water-bath is calculated.

The construction of the so-called calorimetric bombs will not be described in detail as they only differ from one another in details. In general they are cylindrical containers of sufficient strength with screwed-on lids[1] into which is placed a definite weighed quantity of the substance in a small container. The bomb is filled with compressed oxygen. Greater difficulty is encountered in igniting the substance. Actually this is done in that either an electric spark is discharged in the substance and the latter ignited thereby, or a fine iron wire imbedded in the substance, is made red-hot electrically and in this way starts the combustion. The oldest form of the bomb is the so-called Berthelot bomb which, however, is little used as it is lined with platinum and therefore is rather expensive. It has the advantage though of great resistivity and invariability. A few other constructions are those of Mahler, Kroeker and Langbein. More recent bombs are provided with connections to take off and to analyze the gases and especially the water formed during combustion.

Such a bomb is placed into a water-bath, most advantageously in one with double, highly polished walls which can at the same time be stirred. A sensitive thermometer, preferably Beckmann thermometer, is placed in the water bath and the whole calorimeter container is enclosed, in order to minimize radiation influences, in another container so that it is surrounded by an insulating air space. Then the increase in temperature is observed. If certain substances offer difficulties in combustion it is well to mix with them others rich in oxygen, for which case the Parr[2] or Lunge calorimeter is particularly adapted. The procedure of an experiment is now such that the amount of substance taken is such as to create a temperature increase of only a few degrees. The experiment is started by first ascertaining the course of the temperature of the calorimeter water, for a few minutes, timing with a watch. Then at a definite moment the ignition is started and the temperature increase again observed which naturally now is faster.

[1]Note: The bomb with screwed-on lid is unsatisfactory and is obsolete in this country. Three piece bombs are used. See descriptions in this issue.

[2]See description Burgess-Parr Peroxide Calorimeter in this issue.

The observations are made at intervals until the temperature has reached its maximum and the calorimeter gradually cools down again by radiation until a slow temperature drop is attained with certainty which is continued for a while. In order to determine the actual temperature increase independently of external influences and of the original course of the temperature, the temperature readings are best plotted graphically. In Fig. 82

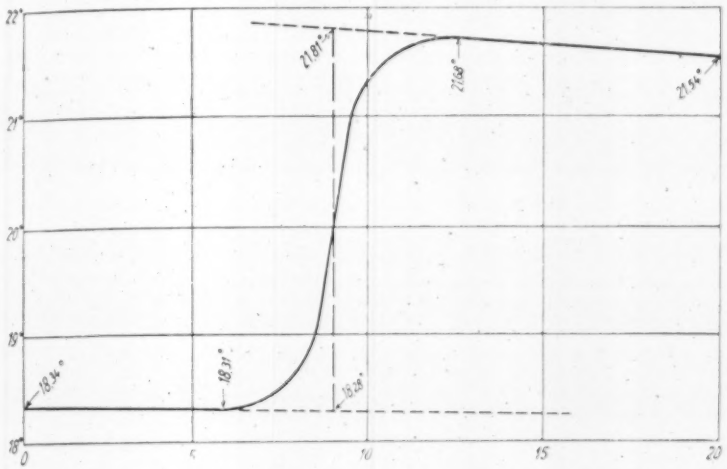


Fig. 82—Calculation of temperature increase for determination of heating values in the calorimetric bomb (ordinates temperatures, abscissae minutes)

is shown the approximate course of such an experiment, at which times the temperatures have been read, and how the course of temperature and the true increase are determined. This is done in that the original temperature curve which runs almost horizontally is extended in a straight line, and likewise the final curve in the direction as it gradually drops. Then the vertical to the time axis is drawn so that the 2 areas between the vertical and the curve of the increase in temperature becomes about equal. The gains and losses of heat neutralize each other. The calculation of the experiment is then made in the following way. If a sample of coal having a weight of 1.306 gm was burned and where an ignition wire of 0.026 gm was imbedded in the sample the net weight of the sample was 1.282 gm. A temperature increase as calculated in the manner described of 3.15°C was observed. The calorimeter consisted of the bomb and the water of a water equivalent determined in some other way, of 2.360 kg. This amounts to a total generated heat quantity of 2360x3.15 = 7434 cal. From tables it can now be seen that iron possesses a combustion heat of 1600 cal. per gram. Therefore, by the combustion of the iron 1600x0.024 = 38 cal. were liberated. The burned coal consequently, generated, 7434 - 38 = 7396 cal, the heating value of the coal is, therefore, $\frac{7396}{1282} = 5760$ cal.[3]

When making this test one more point must be considered which is fairly important. The reliability of the measurement of temperature which is always somewhat difficult can be increased by keeping the starting tempera-

[3]Note: No correction for the formation of nitric and sulphuric acids is included as is required in this country.

ture of the calorimeter below the room temperature about the same amount as the end temperature will be above[4]. This condition contributes considerably to the improvement of the results.

One further point, however, in connection with this simple combustion process must be mentioned, especially with the very widely applied determination of the heating value of coal and similar fuels. During combustion, carbon dioxide and water is formed by the combustion of carbon and hydrogen. Water forms even if the material has been placed in the calorimeter bomb absolutely dry. In general, the combustion gases are cooled to such an extent that the water present is condensed to liquid water. At this condensation a certain amount of heat is naturally liberated which must be determined for each kg of water formed, which according to results of experiment is to be taken as 600 cal. per kilogram of water formed, that is 2 heating values are obtained in the calorimeter according to whether the amount of water generated by the combustion and the heat quantity liberated by condensation is taken into account or not. That heating value referred to water vapor as a combustion product is usually designated as lower heating value, the other as higher heating value. These 2 values are therefore different by the content of water of the combustion products multiplied by 600. The water content can be determined comparatively easily if a suitable bomb is used, as mentioned before, which permits removal of the water from the bomb by introducing dried air and to measure it in some way. The question which heating value is the more important will not be discussed here as this has nothing to do with the measurement itself.

The method of sampling is difficult and actually limits the accuracy obtained. If it is a question of liquids, i. e. fuel oils which can be mixed with ease it is comparatively easy to obtain an average sample; but it is different with coal. For coal, at first a comparatively large amount is taken in an agreed manner—this is spread out and individual samples are taken from different places of the spread samples. The individual samples will then be mixed to a considerably smaller new sample, crushed and again by taking several individual samples a last final sample is made up which then is ground weighed, and placed in the bomb.

It must now be mentioned how the water-equivalent of the calorimeter itself is determined. As already mentioned above the actual numerical or experimental procedure is actually very difficult. For this reason one proceeds by calibrating the bomb by means of standard substances. For such the following may be used:

Cane sugar with 3957.0 cal.
Benzoic acid with 6333.0 cal.
Napthalene with 9667.8 cal.[5]

A suitable sample of one of these substances is burned and the increase of temperature determined in exactly the same way: the water equivalent is now calculated inversely by assuming the heating value as known.

In this manner, solid and liquid substances can be investigated without great difficulty. The investigation, however, takes a different course if one wants to test gases. These must be burned in a suitable burner and the quantity of heat generated is entirely collected and measured. Al-

[4]Note: It is now well known that the procedure given is not at all to be recommended.] The final temperature should be close to the environment temperature.
[5]Note: The values accepted here expressed in 15° calories are 3953, 6335 and 9632, respectively.

though this can be improvised in special cases by a suitable apparatus yet one of the usual instruments for this purpose should be used if measurements of this kind have to be made more frequently, namely the so called Junkers-Calorimeter for gaseous fuels. The gas to be examined is burned in a suitable burner arranged in the interior of a cylindrical combustion chamber through which water in a helical coil is flowing. At each the inlet and outlet of the chamber a thermometer is placed in the path of the water. One proceeds now, for instance, in such manner that the temperature of the incoming and outgoing water is adjusted so that a temperature difference of exactly 10°C exists during the burning of the gas between the two thermometers. The helical coil in the furnace is arranged in such manner that the heat generated by the burner is utilized to the greatest possible extent. If now constant conditions have been established the amount of water which has passed through the combustion chamber is determined when the burner has used just 100 liters of gas. For this purpose, one of the previously described gas meters is inserted in the gas pipe to the burner. The quantity of water, which passed, is then a measure for the heating value directly since one knows at once that 100 liters of the gas have developed a definite number of calories since they have increased the temperature of the measured amount of water by just 10°C. The calculation is now self-evident.

As this test arrangement is somewhat tedious and quite difficult this construction of the Junkers-Calorimeter has been further developed to such a degree that is has become a mechanical one which also records automatically, this is of importance if the composition of the gases varies considerably, i. e. blast-furnace gases. This recording type agrees in principle fully with the one described before and differs from it only in that the 2 thermometers are replaced by 2 thermocouples, which indicate directly the temperature difference. This temperature difference is recorded on the chart, and it is characteristic for the whole construction that the movement of the gas meter is directly geared with the control of the flow of the water in such manner that the flow velocities of the gas and the water is always the same, i. e., that a gas of high value of which a normal amount has passed increases the water temperature more than a gas of low value, or, in other words, that the temperature difference indicated by the thermocouple is directly a measure of the heating value of the gas. If then the apparatus is calibrated in the factory so that the recorder indicates directly heating values, a calculation of the tests is no longer required.

The same arrangement can, by the way, also be used for the investigation of liquid fuels namely if in the original, non-recording type instead of a gas-burner, another suitable burner is used in which the liquid to be examined is burned. The procedure is here such that in the same manner the quantity of water is determined which flowed through the apparatus in a definite time with a known temperature difference, and at the same time a scale is used to determine how many grams of fuel have been consumed during this time. Further details need not be discussed here. But it may be mentioned, that, in the examination of gases, a distinction must naturally be made between the higher and the lower heating value. This is done in this way—and the calorimeter is arranged for it—that the condensed water formed can be collected, and the heat quantity produced by the condensation must, of course, be deducted.

Another circumstance must still be taken care of, that is the correct calculation of the burned quantity of gas. If i. e. 100 liters of gas have pass-

ed the gas meter with a temperature of 23°C, under a pressure of 42 mm water (above atmospheric pressure) at a barometer pressure of 741 mm then the gas was actually under a pressure of 741 + 42/13.5 = 744 mm, its reduced volume therefore, was $100 \frac{273}{273+23} \times \frac{744}{760} = 100 \times \frac{273}{296} \times \frac{744}{760} = 90.4$ liters and with this volume the real heating value must be calculated. If further, it has been determined that the collected condensate amounts to 81 gm then it is clear from the foregoing that 1 cubic meter of gas would yield $\frac{1000}{90.4} \times 81 = 897$ gm water. From this 897x0.600 = 538 cal have been liberated by the condensation, and these have to be deducted from the heating value as determined to find the lower heating value.

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CALORIMETRY

The Examination and Thermal Value Fuel: Gaseous, Liquid and Solid. J. Coste and E. Andrews. 1914. Cloth, 278 pages, $2.75.
The Modern Calorimeter. W. P. White. 1928. Cloth, 194 pages, $4.00.

SURVEYING

Textbook on Surveying and Leveling. Threlfall. 1920. Cloth, 663 pages, $7.00.
Surveying Manual. H. Ives. 1914. Cloth, 296 pages, $2.25.
Technic of Surveying Instruments & Methods. W. Webb & J. Fish. 1917. Cloth, 319 pages, $2.50.
Manual of Underground Surveying. L. W. Trumbull. 1910. Cloth, 251 pages, $3.00.
Surveying Manual. W. Pence and M. Ketchum. 1915. Cloth, 388 pages, $2.50.
Surveyor's Handbook. T. Taylor. 1908. Cloth, 328 pages, $2.50.
Geodetic Surveying and Adjustment of Observations. E. Ingram. 1911. Cloth, 389 pages, $3.50.
The Plane Table and Its Use in Surveying. W. Lovell. 1908. Cloth, 50 pages, $1.00.
The Principles and Practice of Surveying. C. B. Breed & G. L. Hosmer. Vol. I. Elementary Surveying. 1908. Flexible, 592 pages, $4.00. Vol. II. Higher Surveying, 1912. Flexible, 489 pages, $3.50.
Geodetic Surveying. E. R. Cary. 1916. Cloth, 279 pages, $2.50.
The Effects of Errors in Surveying. Henry Briggs. 1912. Cloth, 179 pages, $4.00.
Treatise on Mine Surveying. Bennett Brough and H. Dean. 1926. Cloth, 473 pages, $5.50.
The Elements of Astronomy for Surveyors. R. Chapman. 1922. Cloth, 251 pages, $2.75.
Field Methods in Petroleum Geology. G. Cox, C. Drake and G. Muilenburg. 1921. Cloth, 365 pages, $4.00.

GEOPHYSICS

Elements of Geophysics. R. A. Bronn translated by Margaret Cobb. 1928. Cloth, 372 pages, $5.00.
Elements of the Precision of Measurements and Geophysical Methods. H. Goodwin. 1919. Cloth, 116 pages, $1.60.
Geophysical Prospecting. A. I. M. E. 1929. Cloth, 667 pages, $5.00.

TEMPERATURE MEASUREMENT

Practical Pyrometry. Erwin S. Ferry and Others. 1917. Cloth, 147 pages $1.50.
Methods of Measuring Temperature. Ezer Griffiths. 1925. Cloth, 203 pages, $5.00.
Pyrometry. W. Wood and J. Cork, 1927. Cloth, 207 pages, $3.00.
Elektrische Temperatur-Messgeraete. G. Keinath. 1923. Cloth, 275 pages, $4.00.
Anleitung zu Genauen Technischen Temperaturmessungen. O. Knoblauch and K. Hencky. 1926. Cloth, 174 pages, $4.00.
Les Mesures de Temperatures courantes. W. Deriaz. 1927. Paper, 148 pages. $1.00.

MACHINE SHOP

Gages and Gaging Systems. J. Woodworth. 1908. Cloth, 249 pages, $2.00.
Tool Engineering—Punches, Dies and Gages. A. Dowd and F. Curtis. 1925. Cloth, 341 pages, $3.50.
Modern Gaging Practice. A. Dowd and F. Curtis. 1925. Cloth, 280 pages, $3.00.
Grundlagen und Geraete Technischer Laengenmessungen. G. Berndt. 1929. Cloth, 374 pages, $12.00.
Gauges & Fine Measurements. F. H. Rolt. 1929. Cloth, Vol. I, 366 pages; Vol. II, 357 pages, $14.50.

"That Peculiar Thing, Temperature"

M. F. Béhar*

CALORIMETRY could not be the exact science that it is without exact methods and precision instruments for measuring quantities of heat. Heat itself is a most exasperatingly elusive and unconfinable attribute of matter. No instrument can measure it directly. It is measured by processes of reasoning which, since the time of Watt, Rumford, Gay-Lussac, Carnot, Joule, Clausius and Rankine, have evolved into exact methods. The precision instruments—which give us numerical values as a start for the evaluation of calorific value by exact methods—are thermometers. They measure temperature. Thick tomes have been written on the construction and use of temperature measuring instruments; comparatively little on that peculiar thing, temperature, which they measure. Let us look into it, and into the evolution of scales. It will require a little excursion into the realm of science—just deep enough for the curious but busy calorimetrist to refresh his memory—but the ending will prove of practical value. Two questions are frequently asked. First, what *kind* of a thing is temperature. Second, what is it?

FIRST—"The-thing-which-is-measured" by any instrument or calculation is habitually referred to in technical books as a quantity. Through force of habit this term is applied to temperature—incorrectly, we believe. "The-thing-which-is-measured" by a thermometer is not a quantity. The "hotness" of a body (of steam or ice, of Sirius or of liquid helium), as an object of measurement, is like the "loudness" of a sound or the "brightness" of a lamp. (Even more so, for today the "talkie" technicians can measure intensity of sound in dynes/cm^2. Light flux, too, is expressed in CGS units). Unlike mass or length which are both *extensive* and *additive*, temperature is *intensive*. Temperature is an intensive and *dimensionless* magnitude—one of the few purely such, in all natural phenomena. That's the *category* of a thing it is.

SECOND—What is it? The simplest definition is the schoolboy definition: Temperature is the degree of sensible heat of a body. Lame as it is, it conveys the correct idea but it is bound up with human senses and the imperfections of actual substances.

This definition does not give us properly scaled thermometers, so we must dig deeper. This is what Kelvin did. In 1824 Carnot had laid down his principle of reversibility with regard to "quantity of heat" in an ideal "body" that "undergoes changes," and in 1845 (after 30 years of experiments) Joule demonstrated mechanical equivalence. Heat now became an engineering "quantity," measurable in foot-pounds. But what was temperature? The explanation seems so near, scientists deplored, and yet it eludes us! But look here, the higher the temperature the greater the quantity of heat in Carnot's "body." If we can't ever know what temperature is, can we at least establish its real relation to *heat* independently of the *actual* behavior of mercury, or of a gas (which is an "effect" and not a law) and yet in such a way that we can make thermometers that agree with one another?

*Engineering Editor

Editor's Note: This article will be a part of Mr. Béhar's "Engineers Handbook of Industrial Instruments" when issued in book form.

Yes, said Kelvin in 1848, and in one stroke of genius laid the foundation of "absolute" thermometry. What he did, in effect, was to take the schoolboy definition and put it into Carnot's thermodynamic terms. Reference to a scale is obviously necessary in the case of an "intensive magnitude." Kelvin defined the ideal thermodynamic scale of temperature as such "that the absolute values of two temperatures are to one another in the proportion of the heat taken in [Q_2] to the heat rejected [Q_1] in a reversible thermodynamic engine working with a source and refrigerator at the higher [T_1] and lower [T_2] of the temperatures, respectively."

$$\frac{T_2}{T_1} = \frac{Q_2}{Q_1}$$

Do you recognize the schoolboy definition in Kelvin's use of Carnot's terminology? It is there. For "sensible heat" in the schoolboy definition (which implies properties of substances) Kelvin substituted *available heat energy*—engineering terms. While he may not have used these words, they are obvious to modern readers, and we sometimes speak of Kelvin's "energy definition" of temperature.

But that energy definition was only half of what was done by the young physicist (he was only 24). He took the vague first part of the schoolboy definition, "the degree of," and proposed instead a *scale of availability* of heat energy in an ideal "body," thereby giving us the first standard for the measurement of temperature. For it was not only *a* scale but the thermodynamic expression of *the* scale—The Absolute Scale of Temperature.

Thermometers had been developed long before his time. Galileo, Rey, Newton and Fahrenheit had gone to their reward (*not* in the place where temperature is said to be somewhat unbearable). Daniell had invented a pyrometer in 1825, when Kelvin was a year old. Becquerel had used a platinum-vs-palladium thermocouple in 1826. Thermometry was a highly developed art—almost a science. Young Bill Thompson made it a science.

Speaking of science, we must be exact. Kelvin's definition was in a way too independent of properties of matter. His scale could only be seen with the eyes of reason. It was not until 1854 that he defined the absolute temperature (the familiar capital T or θ of calculations) as proportional to the reciprocal of Carnot's function, and that he began with Joule the porous plug experiments which allowed him to announce in 1862 the practical application of the absolute scale in the making of tangible thermometers with visible scales.

Thus, for any gas selected, we get the pressure, volume and "Kelvin temperature" relations

$$\left(\frac{T}{T_o}\right)_v = \left(\frac{p}{p_o}\right)_v \text{ and } \left(\frac{T}{T_o}\right)_p = \left(\frac{v}{v_o}\right)_p$$

(Incidently they proved that on the centigrade system of numerical values $T_{\text{m.p. ice}} = 273$, and "located absolute zero.")*

*The zero question was first attacked in 1702-03 by Amontons who argued that the zero of his air thermometer would be that temperature at which the "spring" of the air in it was reduced to nothing. On the scale he used the boiling point of water was marked at 73 and the melting point of ice at 51½, so that the zero of his scale was, *perhaps*, about —240° on the Centigrade scale. Lambert (Pyrométrie, 1779) gave the value —270° and observed that this might be regarded as "absolute cold." Laplace and Lavoisier arrived at values ranging from 1,500° to 3,000° below the freezing-point of water, and thought that in any case it must be at least 600° below, while Dalton adopted —3000°C. as the natural zero of temperature! To deprive a body entirely of heat is impossible. Liquid helium has been solidified by Prof. Keesom (1926) at 1.13° Abs. To date, this is probably the "record."

These two men—and many other workers—had begun what is known as the *realization* of scales which are independent of properties of matter. There being no "ideal body," an ideal gas thermometer could not be built, but the absolute gas scale was defined and its "realization" was begun. The deviations of actual gases from the Joule and Gay-Lussac laws were determined, and actual gas thermometers could be and were built, and their readings corrected to give values that were unquestionable.

Kelvin's energy definition was no longer a philosophical concept of no practical value, for it had been related to one of many known and readily observable continuous energy changes in some familiar form of matter, in other words, to thermal properties or temperature effects.

Such effects have been known from ancient times. Many are conveniently observable and are utilized in all instruments, from the simplest to the most elaborate, for the practical measurement of temperature. Among these are: change of length of solids, change in volume of liquids and gases, variation in the pressure of gases and in the tension of vapors, change of electrical resistance, thermoelectric behavior, heat conductivity, color of emitted light, intensity of radiation of all wave lengths, etc.

Thus we have mercurial thermometry, resistance thermometry, optical pyrometry, radiation pyrometry, thermoelectric pyrometry—all used in industrial work—and other methods used in the laboratory.

All of the above are commonly used for determing *unknown* temperatures, As in every other form of measurement, standard references are necessary. In this case the standard references must be fixed temperatures. Nature also affords us a number of these—boiling points, freezing points, etc. Only the scientist is interested in measuring the exact temperature of these points. Sometimes it takes months, even today. The engineer accepts the values given and calibrates his thermometers accordingly.

By putting together the foregoing two paragraphs, it is plain to see the importance of "ideal" scales independent of properties of matter and based on The Absolute Scale of Temperature. We use thermometers when we want to know "what the temperature is." These thermometers are calibrated by reference to fixed points. There is a zero of course, the absolute zero, but it is as impossible of attainment as perpetual motion. We must use "easy" fixed points. But to measure these fixed points we must use thermometers. But we cannot construct a perfect thermometer. But we need properly scaled thermometers to measure unknown temperatures Round and round it goes—or it would go round and round without a solution unless we had a standard of measurement for comparison. Such a standard cannot be like the standard yard or standard pound or standard ohm or numerous other standards expressed in CGS units. Remember—"intensity," "hotness" and "brightness," etc.

Together with the gas laws, Kelvin's thermodynamic scale provided one such standard, as we have seen. And the "gas thermometer," made to definite specifications was the tangible representation of it. Such gas thermometers, installed in Washington, London, Paris and elsewhere, were used for the calibration of various secondary standard thermometers.

Gas thermometers could not be used successfully at temperatures above 1500°C and therefore other laws, properties and effects had to be selected to produce new scales corresponding to the thermodynamic scale and therefore to the absolute scale of temperature.

At this stage of our excursion we leave our hero, Kelvin, and meet another. In fact, several of them. Kirchhoff, first, but he modestly waves us on to Stefan, who steps aside for Boltzmann, who shyly points to Wien, who sends us to Planck, who bows to a great figure whom we recognize: Einstein . . . Which reminds us that time and space (your time and the space of these pages) are limited, and we promised a painless excursion. Let us visit with Stefan and Boltzmann whose achievement, said to be as magnificient as Kelvin's, is nevertheless more easily understood.

To measure a temperature by means of a common thermometer the sensitive part of the instrument must in general "be at the temperature." It must have come to thermal equilibrium with the "body"—or in reality with the *substance*. There must be contact, and heat must flow one way or the other. To break the shackles with which imperfect actual substances fetter us, Kelvin defined the ideal thermodynamic scale in terms of Carnot's thermodynamic body. This was (or we may venture to call it) a *conduction* ideal body. But equilibrium may also be brought about by *radiation*. Must there be contact?

History repeated itself: Kirchhoff defined the *radiation* ideal body—the "black body"—by proving that radiation as a function of temperature is independent of its source. And up rose the cry, Can we forget the Carnot-Kelvin thermodynamic body, and use the Kirchhoff black body?

Yes, said Stefan in 1879, the radiation between two black bodies varies as the difference of the fourth powers of their absolute temperatures. The radiation between a black body at a temperature T and a black "radiometer" at a temperature T_0 is proportional to $(T^4-T_0^4)$. No conduction here, as there was in Carnot's cycle with its two reservoirs. Fair enough. But where is the *proof*? How about *measuring* high temperatures? Can we define a new scale without abandoning the Carnot-Kelvin capital T?

Yes, said Boltzmann in 1884. Correspondence of scales can be proved by substituting radiation for the "working substance" in the Carnot cycle. Radiation energy at any temperature, within or above the accepted gas scale, *per unit volume*, is proportional to T^4.

Stefan discovered the law; Boltzmann proved it. It therefore is known as the Stefan-Boltzmann Law and is the foundation of radiation pyrometry.

$$E = \text{const.}\ T^4 \quad . \quad . \quad . \quad \text{(Stefan-Boltzman law)}$$

The electrical-instrument scales of radiation pyrometers can be calibrated in degrees up to stellar temperatures without any guess-work.

One more visit on our little excursion, and we shall conclude with the synopsis of a great practical achievement. Our last visit is to the German physicist, Wien, who died only recently.

From ancient times blacksmiths and sword-makers had observed that the hotter a piece of metal, the brighter it glowed. "Red hot" and "white hot" always conveyed fairly definite ideas. Modern measurements by various methods resulted in useful color charts. Could not a "brightness" scale be proposed, it was asked in the nineties, so that optical pyrometers could be constructed with scales agreeing with the new radiation scale and hence with the extended standard gas scale? Since the fourth-power law gives the *quantity* of full radiation at T, is it not possible to say how the *quality* varies? Could not "change of color" with temperature be expressed as a law?

Yes, said Wien in 1896, there are several relationships between temperature and the radiation in the spectrum of full radiation, but we must make assumptions about vibrating molecules. Anyway, gentlemen, here you are: The question,—how does temperature affect "color" of radiation?—must be split up into two questions: (1) How does the *wave length* of a full radiator change with temperature? ("Displacement"), and (2) What is the *distribution* of heat energy in the spectrum? The answers are, (1) As to the displacement, I have a formula for the energy density associated with a definite wave length at a definite temperature, and from this I can show that the product of the absolute temperature and the wave length at which the energy density is a maximum is a constant. (2) For the distribution, or "change of color," I have worked out a formula showing just how a *larger part* of the energy is carried in *shorter* wave lengths when the absolute temperature is *increased*.

$$T = \frac{\text{const.}}{\lambda_{max}} \quad . \quad . \quad . \quad \text{(Wien displacement law)}$$

$$E_\lambda = \text{const.}_1 \lambda^{-5} e^{-\frac{\text{const.}_2}{\lambda T}} \quad . \quad . \quad . \quad \text{(Wien distrib. law)}$$

It is not amiss to note here that the old idea of measuring temperature by change of color rested on a flimsy foundation, metallurgists were not estimating temperatures so much by color as by brightness. Incandescent bodies are white at about 1500°C or 2700°F and they stay white above that: They are whiter, or brighter. In some cases brightness may vary twenty times as fast as temperature while color varies very slowly. The original "color" optical pyrometers have been supplanted by the modern instrument which measures monochromatic intensity—the brightness at one "color"—and gives the temperature as Wien proposed.

Wien's molecular oscillation assumptions gave rise to problems which challenged the keenest scientific minds on earth, involving, as Planck found they did, the quantum theory and Einstein's principles of relativity. But the Wien displacement law, as well as his law of spectral distribution of radiation intensity, as modified by Planck, found such acceptance that the optical pyrometer scale, within the range where the Wien law is valid, is one of the international standards.

$$\log E_\lambda = \log \frac{\text{const.}_1}{\lambda^5} - \frac{\text{const.}_2}{\lambda T} \quad . \quad . \quad . \quad \text{(Wien-Planck, practical expression)}$$

It was also found that the "thermocouple effect" (no law to it) gave a very reliable scale, which is used today as an international standard.

The resistance thermometer was found so suitable and convenient for highly accurate measurements that its scale has supplanted the original gas scale as a fundamental international standard. The hour of glory of the Kelvin-Joule gas thermometer is over— but all standard scales conform to the original thermodynamic gas scale, for that corresponded to the absolute scale of temperature.

As to the numerical graduations of scales, the old systems, started by Fahrenheit, Celsius and Réaumur, having been used for centuries, have not been supplanted. The concept of the absolute scale of temperature made

it possible to locate *the* zero of nature but the ice point and steam point (see definitions below) were continued in use for giving the *fundamental interval*, and this fundamental interval of scales has continued to be divided into 100, 180 or 80 equal degrees. It makes it a little harder to work out equations in steam work and wherever we deal with absolute temperatures, but this is a minor difficulty. Temperature being an intensive magnitude, any temperature scale is a scale of intensity and the particular unit adopted makes no differences so long as all scales agree with one another—as they do. Besides, the ice point and steam point are easily reproducible.

So when you come right down to it, that peculiar thing, temperature, that intensive and dimensionless magnitude, is not such a hazy thing after all. It certainly is clearer in any calorimetrist's mind than "force." Just what is . . . but why bring *that* up?

And now we come to the end of our excursion, which leads us at last to the *practical*.

The practical standard of temperature measurement was definitely adopted in 1928 and published in America by the Bureau of Standards (Research Paper No. 22). The title of this document— which is also the name of the practical standard—is the International Temperature Scale. It is simply a practical and common sense *agreement* on (1) the numerical values assigned to a number of basic fixed points, so that they will approximate the ideal values of the thermodynamic gas scale and radiation scale, (2) the class and construction of instruments to be recognized as standards and (3) the simple mathematical formulas for correcting for atmospheric temperature, etc. With proper precautions, such as any engineer would take, and with fairly inexpensive equipment, the International Temperature Scale (meaning the title of the published agreement) ends once for all the mysteries of calibration and standardization. It is above all a practical scale and since it is authoritative, metallurgists and others dealing with high temperatures, where different previous scales gave divergent readings, will do well to use not only the scale but the notations "degrees international" or "degrees Centigrade (international)."

The basic fixed points and pressure corrections of the International Temperature Scale are as follows:

(a) *The Oxygen Point*—Temperature of equilibrium between liquid and gaseous oxygen at the pressure of one standard atmosphere —182.97 Int.

$$t_p = t_{760} + 0.0126\,(p-760) - 0.0000065\,(p-760)^2$$

(b) *The Ice Point*—Temperature of equilibrium between pure, finely divided ice and air-saturated water at normal atmospheric pressure 0.000 Int.

(c) *The Steam Point*—Temperature of equilibrium between liquid water and its vapor at the pressure of one standard atmosphere 100.000 Int.

$$t_p = t_{760} + 0.0367\,(p-760) - 0.000023\,(p-760)^2$$

(d) *The Sulphur Point*—Temperature of equilibrium between liquid sulphur and its vapor at the pressure of one standard atmosphere 444.60 Int.

$$t_p = t_{760} + 0.0909\,(p-760) - 0.000048\,(p-760)^2$$

(e) *The Silver Point*—Temperature of equilibrium between solid and liquid silver at normal atmospheric pressure 960.5 Int.

(f) *The Gold Point*—Temperature of equilibrium between solid and liquid gold at normal atmospheric pressure 1,063 Int.

Standard atmospheric pressure (very important for steam point) is defined as the pressure due to a column of mercury 760 mm high, having a mass of 13,5951 g/cm^3, subject to a gravitational acceleration of 980.665 cm sec.^{2} and is equal to 1,013,250 dynes/cm^2.

The instruments chosen for interpolation and extrapolation lead to a division of the International Temperature Scale into four parts:

1. From 0° C to 660° the temperature t is deduced from the resistance R of a standard platinum resistance thermometer by the formula

$$R_t = R_0 (1 + At + Bt^2),$$

the constants R_0, A, and B being determined by calibration at the ice, steam, and sulphur points, respectively.* The purity and physical state of the platinum should be such that R_t / R_0 shall not be less than 1.390 for t = 100°, and 2.645 for t = 444.6°.

2. From −190° to 0° C, the temperature t is deduced from the resistance R_t of a standard platinum resistance thermometer by means of the formula

$$R_t = R_0 (1 + At + Bt^2 + C[t - 100]t^3),$$

the constants R_0, A, and B being determined as specified above, and the additional constant C by calibration at the oxygen point. The standard thermometer for use below 0° C must, in addition, have a ratio R_t / R_0 less than 0.250 for t = −183°.

3. From 660° to the gold point, the temperature t is deduced from the electromotive force e of a standard platinum versus platinum-rhodium thermocouple, one junction of which is kept at a constant temperature of 0° C while the other is at the temperature t defined by the formula, $e = a + bt + ct^2$. The constants a, b and c are to be determined by calibration at the freezing points of antimony, silver and gold, that for antimony being determined with a standard platinum resistance thermometer, since it lies within the range 0° to 660°.

The platinum of the standard thermocouple should be of the same purity as specified for a resistance thermometer. The alloy is to consist of 90% platinum with 10% rhodium. The couple should develop an electromotive force e not less than 10.2 international millivolts nor more than 10.4 at the gold point.

4. Above the gold point the temperature t is determined by means of the ratio of the intensity J_2 of monochromatic visible radiation of wave-length λcm., to the intensity J_1 of radiation of the same wave-length emitted by a black body at the gold point, by means of the formula

$$\log_e (J_2 / J_1) = 1.432 / \lambda \left\{ 1/1336 - 1/(t + 273) \right\}.$$

This equation is valid if $\lambda(t + 273)$ is less than 0.3 cm. degrees, the constant 1.432 representing the value assigned to Wien's constant of radiation in the same units, and 1336 being the absolute temperature at the gold point.

*The author has it on pretty good authority that when a standardization is requested, the Bureau usually does not give A, B and C but R^0, the F.I. and § or departure of Pt from linearity. Just as good and more convenient!

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by Instruments Book Shelf, Instruments Publishing Company, Pittsburgh, Pa.

GEOPHYSICAL METHODS OF PROSPECTING, PRINCIPLES AND RECENT SUCCESSES. *Dr. C. A. Heiland*, Colorado School of Mines Quarterly, March 1929. Paper, 6 x 9 inches. Price $1.00.

The title of this publication is the best indication of its subjects. It describes all geophysical methods used in practical work to various extents, and also, methods just out of experimental stage. The description of the methods is simple enough to be understood by men not specializing in geophysics, but is not, and was not intended to be used as a textbook.

The compilation of recent successes, sometimes failures, represents fairly, the picture of the present extent of geophysical operations. The accumulation of the data contained in this book must have been a long tedious work and any attempt to check it would mean a repetition of the whole procedure. Information about successes, surveys, localities, seems to be reliable, with a few exceptions of rather minor importance which discrepancies are obviously impossible to avoid in a compilation of this magnitude. The booklet may be the most useful for concerns wishing to embark or be kept informed about geophysical work.—George Steiner.

Handbook of Chemical Microscopy. Vol. 1, Principles and Use of Microscopes and Accessories, Physical Methods for the Study of Chemical Problems. *Drs. E. M. Chamot & C. V. Mason.* John Wiley & Sons, New York, 1930. Cloth, 6 x 9¼ inches, 474 pages. Price $4.50.

With the announcement of this book by the nestors of microscopy at Cornell University, one can almost breathe a sigh of relief and say, "Ah—at last it is here for us all!" Few have had the opportunity of studying under Prof. Chamot at Cornell, some few more have been fortunate in having read his "Elementary Chemical Microscopy," but many will be more than fortunate in having this book. The Handbook, while based primarily on the "Elementary Chemical Microscopy of Dr. Chamot, has been entirely rewritten. So far only the first volume has come from the press. This treats of the principles and use of microscopes and their accessories and physical methods for the study of chemical problems. The second volume will contain chemical methods and inorganic qualitative analyses.

Volume I is divided into 13 chapters and an Appendix. The first four chapters deal with the optical systems of the various microscopes on the market, particular attention being given to their use in the chemical laboratory. The fifth chapter treats of laboratory equipment.

The rest of the book covers ultra-microscopy, photomicrography and microprojection, polarizing microscopy, chemical crystallography, indices of refraction, particle size determination, and quantitative analyses of heterogeneous mixtures. The Appendix contains a synopsis of laboratory practices in the chemical laboratory of Cornell University.

While, to the reader, Chapter V might seem somewhat misplaced and breaking the continuity of thought between the fourth and sixth chapters, which deal with the technique of the microscope and the interpretation of results, it does seem better placed when one realizes its importance in this position, from a pedagogic viewpoint.

While the book seems to have been written essentially for advanced students, it does have real worth to the industrial chemist who has heard so much about chemical microscopy, but who has not had the time to study it. This one handbook is truly a handbook in the volume of material it contains, its numerous diagrams, its very complete bibliographies and the detail with which each subject is treated. No amount of effort has been spared in arranging the infinite amount of detail in a logical order and then presenting it in an easily assimilable manner. To one not necessarily a chemist, to a bacteriologist, clinical diagnostician, metallurgist, or anyone whose daily routine demands an intimate knowledge of the uses of a microscope, although the book treats only of chemical microscopy, it will prove of inestimable value. If the book contained nothing more than those chapters on the use of the microscope and interpretation of results, it would still be worthy of being called the "Book of the Month."

We eagerly await the announcement of the second volume.—Arthur Schroder.

Gas Analysis. *L. M. Dennis & M. L. Nichols,* Macmillan Co., New York, 1929. 6 x 9 inches, 499 pages. Price $4.00.

This book is a valuable contribution to the literature of gas analysis, as until recently up-to-date information on this subject has been rather meager. It has been written more as a text book than for industrial use.

The chapters on combustion of Gases and Heating Value of Gas are especially good. Too much space has, however, been devoted to the Hempel apparatus, which is practically absolete and requires a very skilled operator. More space should have been given to the type of apparatus employed by the United States Bureau of Mines. Also the method of Colman and Smith for the determination of napthalene in gas has been improved, as well as the method for tar fog in gas.

Some of the figures given for the specific gravities of gases do not check with the Bureau of Standards figures. There are numerous references to other literature and the book is very well indexed.—J. M. Gonder.

Spectroscopy of the Extreme Ultra-violet. *T. Lyman.* Longmans, Green and Co., 1928. Second Ed. 160 pages. Price $3.50.

This edition follows the lines of the first as to scope and clarity in style and treatment. Part One contains the introduction and chapters on photometry in the ultra-violet and on absorption of solids and gases. Both chapters differ from those of the first edition only by the inclusion of new material. Part Two has been rewritten and presents a completely new picture both as to technic and results. In the first chapter, on apparatus and methods of investigation in the extreme ultra-violet, the text is considerably changed. A notable addition is the account of the use of a plane ruled grating used at tangential incidence for the study of spectra in the region of soft X-rays and the ultra-violet below the Millikan region. The chapter on absorption and reflection contains a comprehensive treatment of the work performed to date on the absorption and reflecting powers of materials throughout the ultra-violet. Of special interest is the comparison of the reflecting power of various materials upon which gratings are ruled. In the last two chapters, the present edition indicates the greatest departure from the first. In the chapter on emission spectra, the story of the extension of the ultra-violet from 500 A. U. (which was the limit reported in the first edition) to 140 A. U. is found. Chapter Four relates a few outstanding experiments in the field of photo-electric and photo-abiotic phenomena and gives an account of bridging the gap between 140 A. U. and the X-ray region. A table lists the lines of six elements and one compound as observed by different investigators. A bibliography of Schumann's publications, and an appendix dealing with photographic plates for the ultra-violet, are given. Space does not permit the author to discuss the work done on the classification of the series in the ultra-violet of emission spectra but that phase of the field of spectroscopy he treats is thoroughly presented.

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

A New Research Microscope, Model DDE

A NOTABLE contribution to aid the work of the research scientist is the newly designed DDE Research Microscope, the latest product of the Bausch & Lomb Optical Company in Laboratory equipment.

The DDE marks a radical departure from any former type of research and photomicrographic microscope. The outstanding differences in construction from previous types are instantly noted from the illustration.

Most noticeable of these new ideas in design is the inclined position of the binocular eyepiece which allows the user to sit at the instrument in a natural upright and comfortable position. This is an especially commendable feature for continual observation over protracted periods.

The stand of the DDE Microscope also represents an innovation in design, the stage being directly in front of the operator. This "turned about" position offers much greater convenience of manipulation of objects on the stage and of the substage parts.

This new research microscope has been developed by the Bausch & Lomb Engineering Bureau from suggestions first offered by Dr. Lester W. Sharp of Cornell University, with later helpful criticisms submitted by Dr. L. F. Randolph of the U. S. Department of Agriculture and Cornell University.

Designed for Photomicrographic Work. Since the advent of the binocular body, with its necessary prisms and mechanisms, there has been considerable weight placed upon the delicate fine adjustment mechanism. This weight has been too great to secure the responsive action necessary when working at high magnifications. However, the design of the DDE relieves the adjustment of this extra weight. This will be of special value in photomicrographic work where it is necessary to make long exposures.

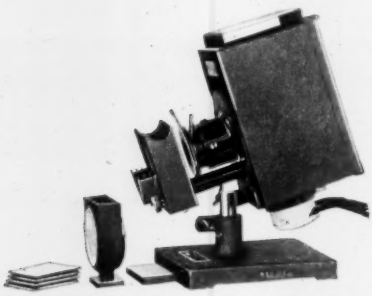
The instrument may be equipped with either the regular single objective binocular body tube for visual use and also for drawing with the camera lucida, or with the single tube for photomicrographic work.

For photomicrographic work the microscope is placed in a horizontal position, resting upon 3 points of support provided on the 2 arms and base. This leaves each part intact and the stage vertical.

Unusual Features in Mechanical Stage and Substage. The mechanical stage has many points which make for unusual facility in research work. It has forward and back adjustment by rack and pinion and transverse adjustment by multiple screw. These adjustments are operated from the right-hand side of the stage and the stage may be completely rotated with the objective in focus without interference. The specimen may be firmly fixed in position—a very desirable feature in photomicrographic work.

The substage is of the usual form, but combines many excellent features for fine focusing of condensers, dark ground illuminators, etc. A novel feature of the substage is a supplementary condenser on a swing arm. The focus of this condenser is so selected that the field of a 16 or 32 mm objective may be entirely filled with light without moving the substage or any of its elements from the usual position for high power objectives. Both high and low powers will function properly without readjustment of the substage condenser.

New Research Lamp Designed. The development of the DDE Microscope made is advisable to design a new type of lamp, one particularly adapted to research microscope work. As a result, the No. 1815 Research Lamp has been produced by B & L as a fitting complement to the new DDE Microscope.



This new lamp meets two requirements which few designs satisfy; the one of utilizing the full aperture of the microscope condenser (up to N.A. 1.40), and the other of transmitting sufficient light to make possible critical illumination of the specimen under observation. Adjustments and focusing devices are conveniently placed and the entire lamp is scientifically correct in every detail.

Wanted: Physicist or Physical Chemist for Instrument Development work. Must be well trained in Inorganic Chemistry, Physics and Electricity. Knowledge of electrical measuring instruments desirable.

Address reply Box M

Instruments Publishing Co.

1117 Wolfendale Street Pittsburgh, Pa.

New Model Wide Field Binocular Microscope

(E. Leitz, Inc.)

THE Leitz Works originated and introduced the low power binocular microscope utilizing wide eyepieces. Various improvements were gradually developed in connection with this type of construction and the latest development in wide field binocular microscopes manifests itself in the new instrument, namely, the binocular microscopes utilizing an automatic multiple objective nosepiece.

Primarily, through the use of oculars of exceptionally large diameter, the wide field binocular microscope yields an extremely large field and offers a long working distance, while at the same time a pronounced stereoscopic field is rendered.

The new prism body supplied with the automatic multiple objective nosepiece permits the use of 3 pairs of objectives, 2 of which can readily be removed from the nosepiece and any of the set of 8 objectives can be inserted in their place. Thus it is possible to avoid the shortcoming evident in many similar types of instruments in that they are either restricted to the use of special objectives or to a very limited number of them.

Magnifications from 5-216x are readily available. The convenience and ease with which this nosepiece functions is truly remarkable.

The prism body, resembling in its general construction the body of the well-known series of "Greenough-Leitz" Binocular Microscopes, is provided with large ocular tubes to accomodate eyepieces of the wide field type. To this body is attached the automatic multiple objective nosepiece. This consists of a strong cover-plate and fastened thereto on its lower surface is a dove-tailed track. On this track the objective carriage slides. The recessed portion of the carriages accomodates in a stationary manner the pair of low power objectives IX. The part which protrudes towards the object stage is equipped with 2 dove-tailed tracks for the accomodation of any two pairs of objectives. These receptacles permit attaching any 2 of the full series of paired objectives, so that at all times the microscope can be equipped with 3 pairs of objectives.

The track on which the objective carriage slides is provided with 3 notches. When sliding the carriage back and forth to shift from 1 objective to another, the carriage spring engages these notches. The right hand side of the objective carriage is equipped with a spring handle and upon releasing same, the carriage automatically moves forward to again be arrested at the next notch, thus placing the second objective into the optical center. The very same procedure repeats itself for the third objective. The backward motion of the objective carriage is accomplished in an identical manner, so that likewise in this way, each of the 3 objectives can successively be located within the optical center. With the rapid and exceedingly simple manner in which the shift from 1 objective to another is accomplished, by means of the spring arresting the objective automatically within the optical center, an important feature is offered, the convenience of which can readily be appreciated through actual use of the microscope.

Through the rigid mounting by means of which the objectives are attached to the carriage and furthermore, the fact that when shifting the objectives they are not touched by hand and not the least pressure being exerted alignment of the optical system is thus guaranteed.

The instrument is furnished in a variety of stands adapted for many modes of investigation both in industrial fields and in educational studies.

BOOKS ON INSTRUMENTS AND DEVICES for Measurement, Inspection and Control

Instruments' Book Shelf is prepared to supply any book or periodical.

METALLURGICAL ANALYSIS

Rapid Methods for the Chemical Analysis of Special Steels, Steel-Making Alloys & Graphite C. M. Johnson. 1920. Cloth, 552 pages, $6.00.
Metallurgical Analysis. N. Lord and D. Demorest. 1924. Cloth, 474 pages, $4.00.
Chemical and Metallographic Examination of Iron, Steel and Brass. W. Hall and R. W. Williams. 1921. Cloth, 501 pages, $5.00.
Technical Analysis of Steel and Steel Works Materials. F. Sisco. 1923. Cloth, 543 pages, $5.00.
Chemical Analysis of Iron. Andrew Blair. 1918. Cloth, 318 pages, $5.00.
Metallurgical Analysis and Assaying. W. McLeod and C. Walker. 1903. Cloth, 318 pages, $4.50.
Select Methods of Metallurgical Analysis. W. A. Naish & J. E. Clennell. 1929. Cloth, 495 pages, $7.50.

CALORIMETRY

The Examination and Thermal Value Fuel: Gaseous, Liquid and Solid. J. Coste and E. Andrews. 1914. Cloth, 278 pages, $2.75.
The Modern Calorimeter. W. P. White. 1928. Cloth, 194 pages, $4.00.

SURVEYING

Textbook on Surveying and Leveling. Threlfall. 1920. Cloth, 663 pages, $7.00.
Surveying Manual. H. Ives. 1914. Cloth, 296 pages, $2.25.
Technic of Surveying Instruments & Methods. W. Webb & J. Fish. 1917. Cloth, 319 pages, $2.50.
Manual of Underground Surveying. L. W. Trumbull. 1910. Cloth, 251 pages, $3.00.
Surveying Manual. W. Pence and M. Ketchum. 1915. Cloth, 388 pages, $2.50.
Surveyor's Handbook. T. Taylor. 1908. Cloth, 328 pages, $2.50
Geodetic Surveying and Adjustment of Observations. E. Ingram. 1911. Cloth, 389 pages, $3.50.
The Plane Table and Its Use in Surveying. W. Lovell. 1908. Cloth, 50 pages, $1.00.
The Principles and Practice of Surveying. C. B. Breed & G. L. Hosmer. Vol. I. Elementary Surveying. 1908. Flexible, 592 pages, $4.00. Vol. II. Higher Surveying, 1912. Flexible, 489 pages, $4.50.
Geodetic Surveying. E. R. Cary. 1916. Cloth, 279 pages, $2.50.
The Effects of Errors in Surveying. Henry Briggs. 1912. Cloth, 179 pages, $4.00.
Treatise on Mine Surveying. Bennett Brough and H. Dean. 1926. Cloth, 473 pages, $5.50.
The Elements of Astronomy for Surveyors. R. Chapman. 1922. Cloth, 251 pages, $2.75.
Field Methods in Petroleum Geology. G. Cox, C. Drake and G. Muilenburg. 1921. Cloth, 305 pages, $4.00.

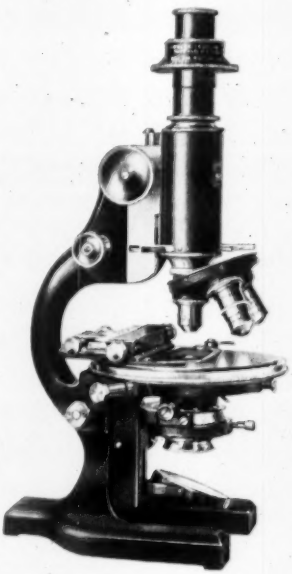
GEOPHYSICS

Elements of Geophysics. R. A. Bronn translated by Margaret Cobb. 1928. Cloth, 372 pages, $5.00.
Elements of the Precision of Measurements and Geophysical Methods. H. Goodwin. 1919. Cloth, 116 pages, $1.60.
Geophysical Prospecting. A. I. M. E. 1929. Cloth, 667 pages, $5.00.

New Chemical Microscope

(Spencer Lens Company)

CHEMICAL microscopes have been found particularly useful in the following types of work: Identification of inorganic or organic substances by micro-chemical tests or by determinations of optical properties examinations of raw materials and finished products in the manufacture and use of chemicals, abrasives, alloys, ceramic materials, drugs and medicinals, explosives, fats, waxes and soaps, fibres, textiles and papers, foodstuffs, leather, minerals, naval stores, pigments, fillers and protective coatings, rubber, wood, cellulose products, etc; measurements of microscopic materials, and the quantitative estimation of the composition of mixtures, especially those which cannot be determined by other methods.



It is entirely satisfactory for any investigation in which a high-grade compound microscope is required and is recommended for biological work involving studies requiring polarized light.

The stand and body tube are the standard size. There is a slot at the lower end for compensators such as a quartz wedge and gypsum plate. This slot is provided with a dustproof shutter. The instrument can be supplied with either a dustproof revolving nosepiece or a quick change centering objective carrier. The *fine adjustment* is the patented combination lever and micrometer type graduated for fractional revolutions of the shaft. The stage is the circular, revolving type, 120 mm. in diameter with centering screws. The periphery is graduated and can be read to three minutes. It is easily removable for cleaning and for replacement by heating and cooling stages. The *mechanical stage* is a new design which revolves with the stage. It is easily attached and when detached leaves a clean, even stage. It is built low so that in revolving it passes under the objectives on the nosepiece when any one is in focus. This stage has a lateral excursion of 75 mm. and a to and from movement of 25 mm. The stage is graduated to millimeters with verniers reading to 1/10 mm. There are buttons for these movements on either side of the microscope, easily available for either hand. The *substage* is the fork-type which holds the substage parts rigidly in alignment and permits convenient and rapid interchange of polarizer, condenser and dark field illuminator. It is focusable by a rack and pinion. Means are provided by which the substage parts always go into the fork in the same way so that there may be no change in the relation of the Nicol to the other parts. Standard RMS adapters are available.

A polarizer for parallel polarized light only is provided with a Nicol prism mounted in a graduated revolving mount with knurl for easy rotation.

Provision is made for fixing the zero point in a definite relation to the optical train. A combination *polarizer with auxiliary condenser* was developed at the suggestion of Drs. Chamot and Mason. This provides for both parallel and convergent polarized light, the latter being necessary for the study of interference figures in crystals. The Nicol prism in its graduated knurled mount can be easily removed without disturbing the condenser. The condenser can be removed, leaving the polarizer in position. The upper lens of this condenser is mounted on a swinging stirrup by means of which it may be swung out of the optical axis, leaving the lower lens to serve as a long focus condenser. An iris diaphragm is beneath the condenser and Nicol. The whole assemblage goes into the substage fork in a way to assure that any readings always designate the same optical relations. The cap analyzer composed of a Glan-Thompson prism is mounted above the eyepiece in a graduated housing which revolves in a collar attached to the upper end of the draw tube. There is a stud to engage a slot in the draw tube so that the planes of vibration of the prisms will coincide with the cross hairs in the eyepiece. The plane of vibration is marked on the mounting.

This microscope was designed as a chemical microscope, but it can be very successfully used as a metallurgical microscope with some slight changes which can be easily made by the operator. The regular stage and condenser can be removed and auxiliary stages can be attached to the substage so that they can be focused up and down. The specimen may be revolved on a vertical axis and moved laterally so that any point in the specimen may be moved through an area of $\frac{3}{4}''$ in diameter. For this work vertical illumination will generally be necessary. All vertical illuminators may be screwed into the body tube between that and the objective.

A new microscope lamp, with a standard voltage high power projection bulb and a pair of condensing lenses and an iris diaphragm, has been developed and is recommended for use with this microscope.

THE specifying of instruments and devices for measurement, testing and control starts with engineers, works managers, research engineers, test engineers, routine laboratories, consulting engineers, etc.

INSTRUMENTS

can assist you in locating both buyer and seller.

New Measuring Instruments

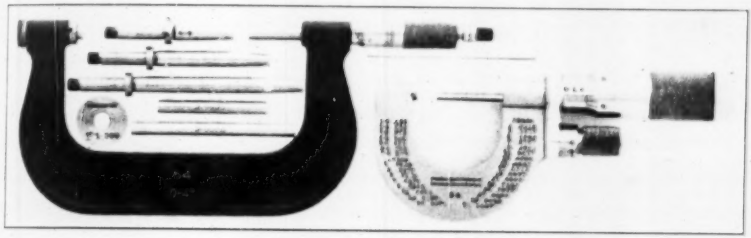
(Brown & Sharpe Mfg. Co.)

Micrometer Caliper No. 24. An entirely new principle in measuring to ten-thousandths of an inch is employed in the Micrometer Caliper No. 24. This tool, with a range of from 0 to 1" by ten-thousandths, reads the ten-thousandth parts of an inch direct.

With Micrometer Caliper No. 24 the thousandths are read from the barrel and thimble in the regular manner and the readings in ten-thousandths of an inch are read directly from the small lower thimble. Note the widely spaced graduations, which permit parts of ten-thousandths to be estimated.

This new Micrometer Caliper is used and operated in much the same way as the conventional, one inch Micrometer. After the spindle has been brought up to the object to be measured, merely turn the small lower thimble until the horizontal line on the barrel of the micrometer coincides with a graduation on the main thimble. The graduation on the small lower thimble then tells the ten-thousandths of an inch to be added to the thousandths reading.

No. 24 is of simple construction, and has no gears or intricate parts to get out of order. Very fine measurements are made with this tool in an unusually easy way.



Micrometer Caliper No. 54 Micrometer Caliper No. 24

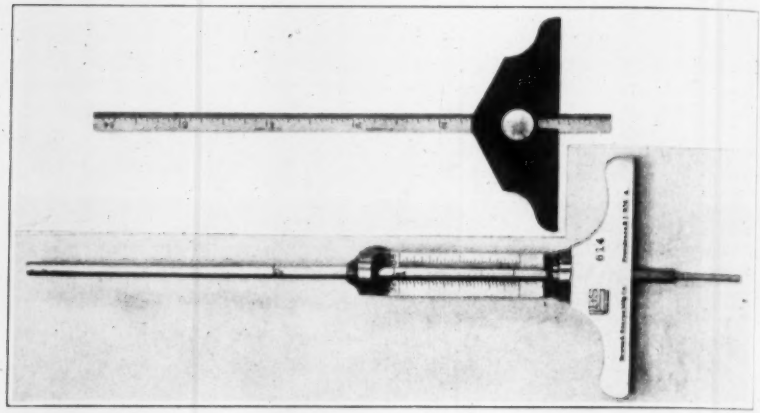
Micrometer Caliper No. 54. The No. 54 Micrometer is a tool which will find favor among a large number of users of machinists tools, since the wide range of measurements of No. 54 makes it a desirable tool for many kinds of work.

The tool is especially adapted for use in the automotive service shop where its range, 0 to 4" by thousandths of an inch, includes practically all automobile parts requiring close measurement. Pistons, cam-shaft bearings, wrist-pins, crank-shaft bearings and pins, and many other parts are measured quickly and accurately with No. 54.

The four interchangeable anvils furnished with this tool make it a micrometer caliper of moderate price which accomplishes the work for which four Micrometers were formerly required.

No. 54 is furnished with ratchet stop and set of 3 standards, unless otherwise ordered. The tool is packed in a finished wooden case.

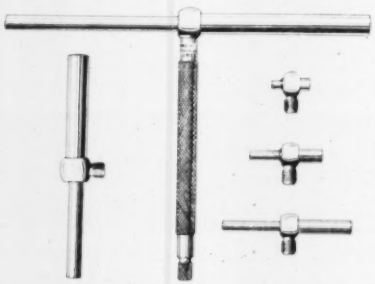
Two New Depth Gages. Graduated Rod Depth Gage No. 614 measures the depth of large or small holes, and the depth from 0 to 3" can be read directly in 64ths from the graduations on the body of the gage. The wide base and the body of the gage. The wide base and slender rod make this tool convenient for use in measuring holes of either large or small diameter. The rod is graduated each inch for three inches. First 5/8" of rod is 1/16" diameter and remainder is 1/8" diameter. Base is 2" wide and 1/4" thick.



Top illustration shows depth gage No. 617. Bottom the rod depth gage

Drill Point Gage and Depth Gage No. 617 is two tools in one. It can be used for checking the angles of drill points when grinding them, and determines whether the point is central; or it may be used as a depth gauge for finding the depths of holes as small as 3/32" in diameter. The graduated bevels on the head are ground to 59°. 6" rule is graduated in 32nds and 64ths of an inch. A 6" rod, 5/64" in diameter, for use in small holes, can also be furnished. No. 617 has a range of 0 to 5". It is also furnished in metric measure if desired.

No. 590 Telescoping Gages. No. 590 Telescoping Gages are comprised of 5 heads which are interchangeable on 1 handle. The telescoping head is inserted into the hole or slot to be measured where it expands to the exact size of the hole. A turn of the knurled screw on the end of the handle locks the head and the gage is then removed and measured with a micrometer.



No. 590 Telescoping Gages

Each head is a self-contained unit—there are no parts to become mislaid or lost. Measuring surfaces of the heads are ground on a radius, adapting the tool for use in measuring curved surfaces.

Photoelectric Spectrophotometer*

THIS instrument, developed by American Photoelectric Corporation and built by Eimer and Amend, is designed for the accurate analysis of emitted, transmitted, or reflected radiation. Its sensitivity is such that it may be employed to measure accurately the relative intensity of individual lines in the spectrum. Its accuracy is within 0.1%. All measurements are made electrically, so that errors resulting from visual observation are eliminated.

The field of application of this instrument is not limited to the visible spectrum, for it can be used to make direct quantitative measurements in the regions of both the ultraviolet and the infrared. For measurements in different regions of the spectrum different light sources and photoelectric cells are employed, as well as different types of spectrometers, but the method of operation is the same, regardless of the spectral region in which the analysis is being made.

Regardless of the kind of material to be examined, whether gaseous, liquid, or solid, whether transparent, translucent, or opaque, the photoelectric spectrophotometer employed will have as essential parts (1) a carrier for the sample, (2) a light source operated by a storage battery, (3) a spectrometer to segregate the lines or bands of the desired wave lengths, (4) the case containing the photoelectric cell unit, electrical circuits, amplifiers, control panel, etc., (5) a galvanometer, and (6) a Wheatstone bridge, usually one of the Kohlrausch type.

Fig. 1 is a photoelectric spectrophotometer designed for making color analyses of transparent substances in the visible spectrum. It consists essentially of (A) a modified Bausch and Lomb constant deviation spectrometer to which a light source has been attached; (B) a case containing the photoelectric devices, on the outside of which is provided an enclosed slide for the material to be examined; (C) a Leeds and Northrup bridge; and (D) a Leeds and Northrup galvanometer. The batteries that are required do not appear in the picture.

Fig. 2 is a photoelectric spectrophotometer designed for making color analyses of opaque substances in the visible spectrum. It consists of (A) a modified Hilger constant deviation spectrometer; (B) an opaque illuminator; (C) the case containing the photoelectric devices; (D) a Kohlrausch bridge, made by Leeds and Northrup; and (E) the same type of galvanometer as shown in Exhibit 1.

Fig. 3 is a photoelectric spectrophotometer designed for the determination of the relative energy distribution in the ultraviolet. It consists of (A) a modified Hilger quartz spectrometer; (B) the case containing the photoelectric devices; (C) a Kohlrausch bridge; and (D) a Leeds and Northrup galvanometer. It is, of course, understood that when working in the ultraviolet, whether with transparent or opaque substances, that a light source is employed which is rich in ultraviolet rays, e.g. a quartz-mercury arc, and that all parts of the instrument through which light passes are of quartz.

*Patents Pending

To make a reading on any material at any desired wave length, it is necessary only to balance an electrical circuit by turning a dial similar to those on radio sets, and then, after interposing the material under examination, again to balance the circuit by turning another dial on which is read directly in percent the proportion of the total light of that particular wave length which is transmitted or reflected by the material. A sufficient number of readings at different wave lengths are made to enable one to plot an accurate curve of intensity versus wave length over any desired range of the spectrum. Technical skill is not essential, and anyone, after a few minutes of instruction and practice, can obtain accurate results. A complete set of measurements in the visible spectrum can be made in about five minutes, individual readings requiring from fifteen to twenty seconds.

Sample carriers and light sources are so constructed, and spectrometers are so modified, that the instrument may be operated in a lighted room, which increases the facility and speed with which determinations can be made. In this connection, it should be noted that the light source is of the low voltage and low current type, which eliminates many difficulties encountered in other color analyzers where the light source consumes 500 watts or more. For example, for transmission measurements the light source in this instrument consumes but 15 watts, and for reflection less than 100 watts.

All determinations are independent of the color and intensity of the light source, and it is not necessary for the electrical circuit to be kept constant throughout a series of readings in order to insure accuracy of measurement, because with this instrument measurements are independent of gradual variations either in the light source or in the photoelectric cell. Since the determinations are independent of empirical values or standards, the results may be expressed in any convenient terms such as total reflection, spectral centroid, etc. Readings may also be secured directly in terms of eye sensitivity, or in terms of any theoretical or real color standards.

At this time it might be mentioned that in the laboratories of American Photoelectric Corporation two color analyses were made of the same sample of cottonseed oil using for the different analyses different apparatus throughout; i. e. different types of light source, different makes of spectrometers, bridges and galvanometers, and even different types of photoelectric cells, and yet the two color analyses were substantially identical, the maximum variation at any point in the spectrum being less than 0.1%.

In the field of physical research this instrument offers a means for securing fundamental data on the characteristics of radiant energy and on the structure of matter. For example, by the accurate measurement of the relative intensity of individual lines in the spectrum, it may be employed for the differentiation of isotopes.

This instrument already has found employment in many industries, such as those engaged in the manufacture or use of dyes, paints, textiles, paper, animal and vegetable oils and fats, petroleum products, glass, moving pictures, etc. where accurate determination of color is of importance. It is beginning to find applications in other industries where color can be used as a critical index to accurate control of production when its measurement can be made quickly, easily and exactly.

A modification of this instrument may be used as a pyrometer for the precise measurement of the temperature of steels or other materials during heat treatment, it being possible to detect a change in temperature as little as one degree Centigrade by this means.

Similarly, by still another modification of this instrument, it is possible to measure sound.

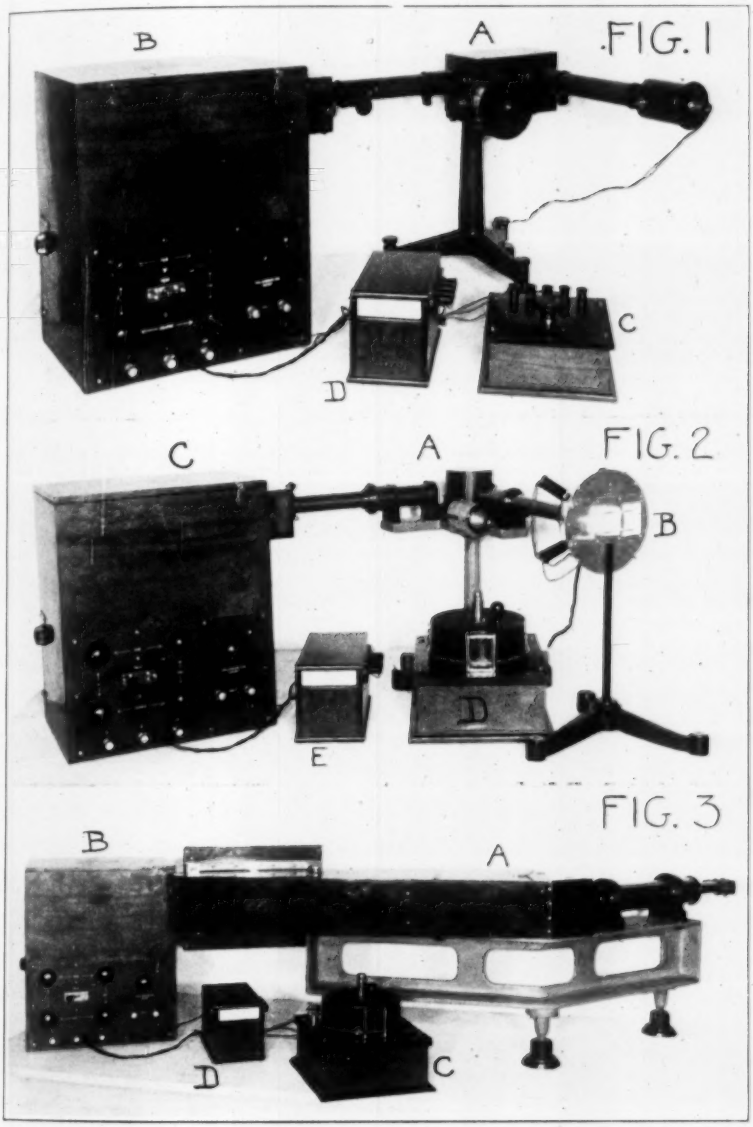


FIG. 1

FIG. 2

FIG. 3

Improved Hay's Orsat

(Hays Corporation)

IT has been the aim of The Hays Corporation Engineers to present an even more compact, rugged and ingenious gas analyzer with those features of design and construction demanded by combustion engineers, service engineers, oil burner installers, consulting engineers, operating engineers and others who use such equipment.

Six standard ranges are available in a light weight metal carrying case weighing only 8 pounds complete and measuring 15″ high x $7\frac{3}{4}$″ wide x $4\frac{1}{4}$″ deep. In addition there are three special ranges available in a slightly larger case.

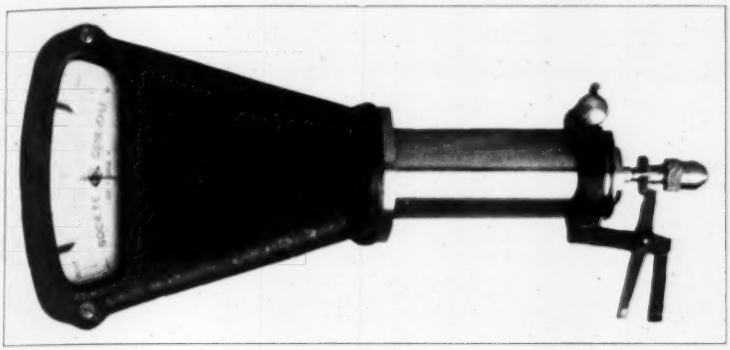
Features of the improved gas analyzer are:

1. Light weight and compact design.
2. Heavy molded glass absorption pipettes which are attached to the molded hard rubber chemical bottles with soft rubber gaskets and finger compression nuts.
3. Steel wool surface method of absorption of the gases being analyzed, making it possible to take a CO_2 reading in 30 seconds and a complete analysis for CO_2, O_2 and CO in from 4 to 5 minutes.
4. Monel metal needle valves and easily renewable nickel needle valve seats instead of pinch clamps and glass stop cocks.
5. Molded hard rubber chemical bottles held in place by slidable flat spring which can be raised after loosening the holding screw, permitting disassembly of the entire instrument for cleaning within two minutes' time. All parts are accessible. Only a pair of pliers and a screw driver needed to completely disassemble the instrument.
6. Owing to the method of supporting the few glass parts in the metal case there is little danger of breakage. All parts, however, are easily renewable in the field.
7. The instrument may be carried in any position without the liability of spilling or mixing the solutions.
8. The leveling bottle and the aspirator and tubing are clamped inside the case after completion of tests. When the doors are closed all accessories are inside the carrying case, with the tubing so arranged on convenient reels that kinking is not possible.

New Micro-Indicator Tube for Precision Comparisons

(R. Y. Ferner Co.)

THE Societe Genevoise d'Instruments de Physique are offering a new form of their micro-indicator tubes for use with the various types of supports they supply for the accurate checking of parts by comparison with standard gages or gage blocks. This new tube, shown in the illustration, has a fan shaped dial which gives a range $2\frac{1}{2}$ times that of the cylindrical indicator previously supplied.



These tubes have a knife-edge multiplication system, the distinguishing patented feature of which is use of a yoke at the upper end of the contact plunger which passes about the fixed knife edge mounted in the tube and carries the movable knife-edge with the edge pointed downward and bearing when in contact, against the rocking plate lying between the 2 knife edges. This plate carries the pointer and is pulled against the upper, movable knife edge by a helical spring which exerts a pull of only $\frac{1}{3}$ of an ounce. When the contact plunger is raised, this rocking plate follows the moving knife edge only as far as the range of movement of the pointer permits, beyond which the knife edge can move a further amount to give a total travel of the anvil of 0.03″ which gives ample room for inserting the work piece under the anvil without injuring the latter by rolling or sliding friction. A pair of levers is provided for attachment about the bottom of the tube to raise the anvil in this way.

This construction of the knife edges, which provides for separation of the knife edges when the plunger is raised instead of transmission of the motion to the lower knife edge, relieves the knife edges of the damaging effects of shocks on the contact plunger which would otherwise dull the knife edges. It is obvious that the knife edges must be very sharp to give a constant amplification throughout the whole travel of the pointer.

With the fan-shaped dial an angular swing of the pointer of over 32° is obtained, which makes it possible to use a more open scale as well as to have a greater range. With the multiplication of the system adjusted to a 400:1 ratio 2 scales are used, 1 having 60 divisions, each division being about 0.04″ wide and representing 0.0001″ so that the range of the scale is 0.006″;

the other scale has 30 divisions twice as wide as the above, each representing 0.0002″ and so giving the same range of 0.006.″ With a multiplication of 120:1 in the system a third scale is used having 40 divisions each of which is 0.06″ wide and represents 0.0005″ and so gives a range of 0.02.″ Dials of dull white celluloid with sunken printed division lines of black contribute to easy reading.

The pointer is made of a very light and resistant hard steel wire, the lower end consisting of 2 branches or legs for attachment to opposite sides of the plate which lies between the knife edges so that practically no deformation of the pointer can take place and the device will work equally well whatever the inclination of the instrument. At the upper end the pointer is flattened out and made wider to give good visibility, and terminates in a thin point which permits very accurate readings. The tip of the pointer is coated with a bright red color for greater contrast.

Two tolerance indexes, colored red, are adjustably mounted in a slot above the dial within a cover over the dial which can be readily removed for adjustment of the indexes. The cover, however, protects them from accidental movement or the cover may be sealed to prevent intentional displacement. With these tolerance marks set at the upper and lower limits for any part being measured these indicators can be used for rapid inspection of parts as well as for measurements of the highest precision.

The contact plunger at the lower end of the indicator has an extremely hard flat anvil surface which has been lapped so that it is exactly perpendicular to the axis of the tube. This anvil is 0.2″ in diameter.

Other types of anvils can be readily slipped over this anvil and seat firmly on it. One of these, which is regularly furnished with the instrument, is a new type of spherical contact point consisting of a hard steel ball held in a holder consisting of two parts which screw together. This permits loosening the ball and turning it to another position if it becomes flattened with wear; or the ball, which is 7 mm in diameter, can be readily replaced when too badly worn for further use.

Other types of anvils which can be supplied as extras include an optically flat anvil of 10 mm (13/32″) diameter which can be slipped over the end of the plunger in place of the spherical contact point; also a hinged flat anvil of 30 mm ($1\frac{3}{16}$″) diameter suitable for checking the true running of lead screws of a lathe or of a worm screw or of a threaded part in process. A third anvil, hinged like the previous one, has a flat surface of 20 mm (25/32″) diameter and is specially suitable for measuring the thickness of paper sheets, cards, cloth, and very thin aluminum and similar sheets. A fourth anvil is of the rocking type, having a lever about $2\frac{1}{2}$″ long pivoted at its center and mounted on a holder for attachment about the lower end of the table with one end of the lever bearing against the spherical contact point when in place on the tube and the other end fitted with a hardened anvil surface on its upper side to permit taking measurements against the under surface or internal surface of a workpiece.

The cylindrical part of the micro-indicator has an outside diameter of 30 mm (1.1811″) and a total length, including the space required for the lifting levers, of $2\frac{7}{8}$″ which is reduced to $3\frac{1}{4}$″ when the lifting levers are used. The downward pressure of the spring which holds the plunger in contact with the object being measured is 300 grams (about $10\frac{1}{2}$ oz.).

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CALORIMETERS AND ACCESSORIES. Catalog C-2 gives information, specifications and prices on calorimeters. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

STEAM CALORIMETER. Bulletin describes the Ellison U path steel calorimeter and gives its principal of operation. Lewis M. Ellison, 214 West Kinzie Street, Chicago, Ill.

GAS CALORIMETER-RECORDING. Leaflet describes the Sarco Recording Gas Calorimeter. Sarco Company, 183 Madison Ave., New York, N. Y.

JUNKERS CALORIMETER. A 32 page booklet 8x11½ inches describes and illustrates: the simple caorimeter for gas; the simple calorimeter for alcohol, benzol, benzine, petroleum, oils and mixtures and the automatic indicating and recording calorimeter for gas. Junkers & Co., Dessau, Germany.

BURGESS-PARR SULPHUR BOMBS. Booklet 108, 5x7 inches, 30 pages, contains directions for using the sulphur bomb and the sulphur photometer. Burgess-Parr Company, Moline, Ill.

BURGESS-PARR PEROXIDE CALORIMETER. Booklet 109, 5x7 inches 28 pages, contains directions for using the peroxide calorimeter and total carbon apparatus. Burgess-Parr Company, Moline, Ill.

CALORIMETRY. Bulletin A-2, 6x9 inches, 43 pages. The introduction briefly considers the testing of gas. The booklet gives instructions for the operation of the American calorimeter. American Meter Company, 165 West 40th St., New York, N. Y.

ECONOMICAL PRODUCTION OF GAS. Publication T M-2, 8½x11 inches, 36 pages. This book describes the Total Heat Meter and Total Heat Controller. Cutler—Hammer, Inc. Milwaukee, Wis.

BRADY B. T. U. INDICATOR. Booklet 6x9 inches, 7 pages describes the Brady B. T. U. Indicator for determining the heating value of either carburetted water gas or coal gas. U. G. I. Company, Philadelphia, Pa.

METHODS FOR DETERMINING THE THERMAL VALUE OF GASES. Four page reprint from Gas Age-Record, describing the Loeffler Calorimeter. Alpha-Lux Company, Inc. 192 Front St., New York, N. Y.

ROSENHAIN FUEL CALORIMETER. List No. 158 gives information on the Rosenhain Fuel Calorimeter. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

A NEW CALORIMETER BOMB. A reprint from "Brennstoff-Chemie." This is printed in German. Franz Hugershoff, G. m., b. H., Leipzig, Germany.

STEAM SEPARATING & WIRE DRAWING CALORIMETERS. Leaflet C-10 describes devices for determining the amount of priming water in steam. Dobbie, McInnes & Clyde, Ltd., 57 Bothwell St., Glasgow, Scotland

RECORDING GAS CALORIMETER. Leaflet describes the Johnson Recording Gas Calorimeter. Gas Producer & Engg. Co., Coatesville, Pa.

BERTHELOT-MAHLER-BOMB CALORIMETER. Booklet, 8½x11 inches, 8 pages. Instructions for use. A. Gallenkamp & Co., Ltd. Finsbury Square, London, E. C. England.

INVESTIGATION OF FUELS. Book, 5½ x8¼ inches, 40 pages. The subject matter of the book is the investigation of heat value of fuels. Franz Hugershoff, G. m. b. H., Leipzig, Germany.

MEASUREMENT OF COKING HEAT. Leaflet KG271 describes the Terres and Wolter calorimeter for the measurement of coking heat. This is printed in German. Dr. Taurke, Dortmund, Germany.

MICROCALORIMETER. Druckschrift 17 27 describes the Roth microcalorimeter. Franz Hugershoff, G. m. b. H. Leipzig, Germany.

CALORIMETER FOR SOLID AND LIQUID FUELS. Booklet, 6¼x9½ inches, 14 pages. Booklet describes the Berthelot-Mahler-Kroeker calorimeter. This is printed in German. Julius Peters, Berlin N. W. 21, Germany.

AIR METERS. Leaflet describes meters for measuring compressed air. New Jersey Meter Company, Plainfield, N. J.

BELL METER. Leaflet No. 110x illustrates and describes the Boys Bell meter for the measurement of gas. Griffen & Tatlock, Ltd., Kemble St., London, W. C. 2, England.

BLAETTER FUER UNTERSUCHUNGS UND FORSCHUNGSINSTRUMENTE. The December issue of this house organ has articles on the lighting arrangements for opaque objects, the testing of objectives and a historical article on the origin of microscopic lighting arrangements. Emil Busch A. G., Rathenow, Germany. This is printed in German.

CAPACITORS FOR POWER FACTOR CORRECTION is the title of Circular No. 1670-B. This circular briefly discusses the causes of low power factor and means of correcting it. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

COMMERCIAL LIGHTING. This catalogue gives the procedure for designing a lighting system and a list of the Westinghouse installations, as well as sizes and prices of all different types of lighting fixtures. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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CURRENT LITERATURE REVIEW

Abstracts on instruments and devices for measurement, inspection and control.

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GENERAL

The Value of the Scientific Instrument Industry to the Life of the Country. H. Howe. Journal Optical Society, October 1929, pages 187-189.

Abstract of an address delivered before the annual meeting of the Scientific Apparatus Makers of America, Atlantic City, May 16-18, 1929.

Fundamentals of Correct Metering. E. C. Goodale. Pt. 1, Electrical West, August 1, 1929, pages 72-73; Pt. 2, September 1, 1929, pages 126-127.

Discusses Blondel's theorem and gives an introduction to its use as a criterion of correct metering. Pt. 2 illustrates the application of the theorem to the metering of three and four-wire circuits.—M.S.

SPECIAL

Electrostatic Load of Persons and its Measurement. (Elektrische Ladungen von Personen und ihre Messung) A. Flad. Siemens Zeitschrift, August, 1929, pages 499-501.

The conditions responsible for the electrostatic charge of persons, which occasionally amounts to 4,000 volts, is discussed. The instruments, their mode of operation and results obtained are discussed and graphically presented. E. F.

Old and New Methods for the Determination of Corrosion and of Protection Against Corrosion (Ueber alte und neue Verfahren zur Feststellung der Korrosion und des Korrosionsschutzes) L. W. Haase. Gas und Wasser, July 15, 1929, pages 1129-1136.

The author critically discusses the manifold methods to determine the degree of corrosion on one hand and the corroding power of different solutions upon various metals on the other. E. F.

Slagging Test for Refractories. Fuels & Furnaces, August 1929, pages 1219-1220.

Abstract of a paper presented before the American Society of Mechanical Engineers in Rochester, N. Y. Describes the furnace and method developed which gave a satisfactory simulated service test of the slagging effect of coal ash.—M. S.

Testing and Rating of Fuel Fired Industrial Furnaces. Pt. 8, Thermal Capacity Curves. Fuels & Furnaces, August 1929, pages 1187-1212.

Discusses method of constructing such curves for the products of combustion, the air required for combustion, and the various fuels, both from theoretical and actual conditions.—M.S.

A Portable Electric Harmonic Analyzer. R. Thornton Coe. Journal Institute Electrical Engineers, October, 1929, pages 1249-1259.

This paper describes a perfection of the dynamometer method of harmonic analysis in which accuracy and speed of operation have been combined with portability. The operation of the analyzer is described in detail. A few examples of its use are also given.—M.B.R.

Rate of Burning of Individual Particles of Solid Fuel. H. K. Griffin, J. R. Adams and David F. Smith. Industrial & Engineering Chemistry, September 1929, pages 808-815; Blast Furnace & Steel Plant, Sept. 1929, pages 1368-1373.

An apparatus and method are described for determining the rate of burning of individual particles of solid fuels under controllable conditions of furnace temperature, particle size and oxygen concentration. The apparatus consists of a nichrome-ribbon furnace in which the particles are burned and a revolving-drum camera for determining the period during which each particle is in process of combustion.—M. E. H. & M. S.

Installation of Gelap and Siemens and Halske Apparatus on the New Ocean Liner "Bremen" (Ausruestung des neuen Schnelldampfers "Bremen" mit Gelap—und Siemens & Halske-Apparaten). H. Frank. Siemens Zeitschrift, Sept. 1929, pages 533-536.

Instruments of the Gesellschaft fuer Elektrische Apparate-Marienfelde and of Siemens & Halske as electrical signal and controlling instruments of the new German liner "Bremen" are described. The electrical signals are particularly mentioned.—E. F.

Thermo-Electric Tests for Aluminum Manganese and Other Alloys. C. S. Taylor & J. D. Edwards. Preprint American Electrochemical Society, Sept. 19-21, 1929, 4 pages.

A thermo-electric apparatus for distinguishing pure aluminum from Al alloys containing Mn is developed. The instrument is also applicable for testing magnesium base alloys containing Al against pure Mg. The galvanometer deflection is roughly proportional to the percentage of Al present.—E. F.

Computing Attachment for Comparators. K. Burns. Journal Optical Society, Oct. 1929, pages 250-252.

Describes a computing attachment, for comparators, designed and constructed by Burns and Curtis at the Allegheny Observatory.

Methods in Metallurgical Research. Walter Rosenhain. Heat Treating & Forging, November 1919, pages 1454-1459.

First part of a paper read before the Institute of Metals. Deals with thermal methods, gradient furnaces, optical pyrometry, thermal analysis, electrical resistance methods, and the dilatometer. —M. S.

Furnace Control in Glass Furnace Operation (Mechanisierung der Feuerfuehrung in Glasofenanlagen) W. Friedmann. Glastechnische Berichte, Sept., 1929, pages 217-241.

Paper presented at the 11th Glastechnische Tagung Vienna, fully outlines a) the problems encountered in furnace regulation, b) the principal features of the regulators including direct and indirect ones of pressure, draft, proportioning and temperature regulators, auxiliary forces for multiplying the regulating force, peculiar devices to avoid over-regulation or surging, c) examples and proposals as gas pressure regulator, steam addition regulator, proportion or mixture regulators, temperature regulators for various service conditions, further applicabilities of automatic equipment centralisation of measurement.—E. F.

(Current Literature Review continued on Page 20)

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Electrical Depth Indicator for Hoisting Shafts. (Elektrischer Etagenanzeiger fuer Foerderanlagen) Siemens Zeitschrift, October 1929, pages 647-648.

The disadvantages of the costumary method of marking the rope are summed up and the new depth indicator is introduced which is based on the same principle as signal devices and electrical remote water level indicators, i. e. on a A. C. magnet system. The new apparatus contains 2 annular scales with an indicator: one for coarse reading and the other for adjustment.—E. F.

Wear of Rails and its Measurement (Schienenabnutzung und ihre Messung) Dr. Kuehnel. Organ fuer die Fortschritte des Eisenbahnwesens, Oct. 15, 1929, pages 418-423.

Paper presented before the Schweizerischer Verband fuer Materialpruefung, March 1928 Zurich, deals with measurement of rail wear by means of the testing machines of Mohr & Federhaff Amsler and Spindel, the results of which are presented in diagrams and tables.—E. F.

A Hot Wire Method for Determining the Longitudinal Spacing of Vortices. E. Tyler. Journal Scientific Instruments, October 1929, pages 310-314.

The paper describes a method of measuring the longitudinal spacing (l) of vortices formed behind a stationary cylinder placed in an air stream. It is based upon the fact that the velocity fluctuations at 2 points in a vortex row are in phase when the longitudinal distance between the points is equal to the distance between successive vortices in the same row, or a multiple of this distance. By employing 2 electrically heated platinum wires, coupled to a vibration galvanometer, previously tuned to the frequency of formation of the vortices, and each wire suitably placed, one in each vortex row, these points have been located differentially.—M. B. R.

A Universal X-ray Photogoniometer. J. D. Bernal. Journal Scientific Instruments, October 1929, pages 314-318; November 1929, pages 343-353

Part III gives a detailed description is given of the instrument in its latest form, the mode of description being such as to facilitate a future account of its adjustment and uses. Part IV gives an account of the adjustment of the instrument and its uses, together with information on the selection and setting up of crystals.—M. B. R.

Cinematogrametrical Determination of Airplane Movements (Kinematogrammetrische Bestimmung von Flugzeugbewegungen) P. Raethjen. Bildmessung & Luftbildwesen, September 1929, pages 121-137.

The article fully details the instruments for taking pictures on films of flying aircraft and the evaluation of the measurements. It is stated that at least 5 pictures must be taken per second. The necessity of accuracy in time and special measurement is shown, and a minimum of 1 600 for angle measurements and 1 600 second for time measurements is urged. The further requirements and the practical solutions are given in detail.—E. F.

On Shrinkage of Metals (Einiges ueber die Schwindung von Metallen) F. Sauerwald. Zeitschrift fuer Metallkunde, September 1929, pages 293-296.

In this paper presented before the Deutsche Gesellschaft fuer Metallkunde, the author attributed the shrinkage of metals to physical constants on one hand and to conditions prevailing during casting at the other side. For the determination of these influencing factors of the foundry, the author and his collaborators developed a special apparatus. E. F.

On Wear of Material Under Dry Friction (Ueber Verschleissbarkeit der Werkstoffe bei trockener Reibung) M. Fuechsel. Organ fuer die Fortschritte des Eisenbahnwesens, October 15, 1929, pages 413-417.

After discussing the wear forces as pressure, slip, velocity of rolling, temperature, atmospheric oxygen and substances between say rail and wheel, the author considers the counteracting properties of the material in regard to its surface conditions, mechanical properties, composition, deteriorations, grain and structure. The customary testing methods and machines, especially the latest improvements are reviewed and practical experiences given.—E. F.

The Analysis Ultra Lamp of Dr. F. W. Mueller (Die Analysen-Ultra -Lampe nach Dr. Ing. F. W. Mueller, Essen) K. Goetze. Chemiker Zeitung, October 23, 1929, pages 824-825.

The significance of the source of light and the filtering of the emitted radiation in investigation of materials by luminescence is discussed and the mercury vapor quartz lamp compared with the new analysis lamp operating with special carbon electrodes.—E. F.

Progress in Irradation by Means of Ultra-Violet Rays. (Progres realises dans le domaine de l'irradiation au moyen des rayons ultra-violets) A. Salmony. Chimie & Industrie, August 1929, pages 259-260.

The quartz lamp, its range and utilization in chemistry, biology and therapeutics is mentioned. Two principal troubles encountered in the application of the quartz lamp, the formation of ozone which produces uncontrollable secondary effects and the decomposition of liquids etc. exposed to radiation are described and the recent improvements outlined avoiding those inconveniences. The utilization for vitaminising milk is detailed and the large unit described.—E. F.

Device for Measuring the Length of Hoisting Shaft Ropes During Rope Inspections (Vorrichtung zum Messen der Laenge von Foederseilen bei Seilpruefungen) H. Adam. Glueckauf, October 12, 1929, pages 1426-1427.

The following advantages are claimed for this new instrument: a) the length of ropes can be read off directly, b) damaged parts of the rope can be determined in centimeters, c) saving of time and money, d) location can be repeated at any time thus increasing safety.—E. F.

MISCELLANEOUS

Studies of Over Voltage on Metals. P. Sederholm & C. Benedicks. Preprint American Electrochemical Society, September 19, 1929, 15 pages.

The effective magnitude of the cathodic voltage is known to be strongly affected by the overvoltage and no corroding current arises if the potential of the local element proper does not exceed the overvoltage. The apparatus of earlier investigators has been considerably modified for the study of overvoltage on metals. The exhaustive investigations are fully detailed in the paper.—E. F.

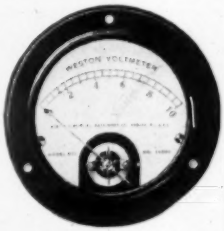
A Combination Electrochemical Switchboard. W. Faitoute Munn. Industrial & Engineering Chemistry, Analytical Edition, October 15, 1929, pages 208-209.

This new compact switchboard may be used for deposition of metals, pyrometry measurements, low-voltage testing of primary batteries, ampere readings, millivolt readings. Diagram is given.—M. E. H.

Microphones for Use in the Laboratory. E Simeon. Journal Scientific Instruments, September 1929, pages 280-283.

Microphones of the moving-coil and electrostatic types respectively are described and discussed. Both types are free from erratic variations in working.—M. B. R.

(*Current Literature Review continued on Page 22*)



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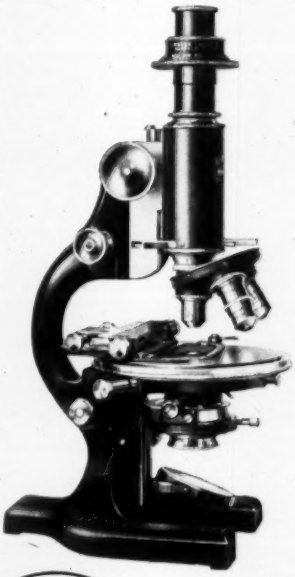

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The Heat of Formation of Sulphur Dioxide. J. R. Eckman & F. D. Rossini. Journal of Research, October 1929, pages 597-618.

The heat of formation of sulphur dioxide has been redetermined. Since the burning of sulphur in excess oxygen results in the formation of varying small amounts of sulphur trioxide, which involves some 90,000 more joules per mole in its formation than does sulphur dioxide, the difficulties involved in analyzing the combustion products for the trioxide and in making the corresponding corrections were obviated by the use of specially designed calorimetric reaction chamber in which oxygen reacts with an excess of hot sulphur vapor to form pure sulphur dioxide. The heat of formation of sulphur dioxide at 25°C. from rhombic sulphur and gaseous oxygen was found to be +296,800±200 absolute joules per mole.

Testing of Glazes. Ceramic Age, November 1929, pages 179-184.

A resume of literature and developments regarding tests for crazing and hardness.—M. B. R.

Quality Control of Raw Materials and Stocks in Process. W. J. Geldard. Rubber Age, November 25, 1929, pages 192-193, 203.

The methods of control in rubber plants is considered. The raw materials are sampled and tested upon receipt. Accepted material is placed in stores. The control of uniformity in processing is taken up.—M. B. R.

Static Measurements for Warnings of Storms. S. W. Dean. Science, May 17, 1929, page XII.

Static troubles of the radio as a warning of approaching storms are discussed. Abs. Bull. Kodak Res. Labs.

Inspection and Testing of Mine-Type Electrical Equipment for Permissibility. I. Ilsley, E. Gleim & H. Brunot. Bureau of Mines, Bull. 305, 26 pages.

This publication discusses the theory upon which tests of equipment in explosive atmospheres are based and to consider inspection and other matters pertaining to complete investigations of machines.—M. B. R.

Plaster-Model Method of Determining Stresses in Curved Beams. F. Seely & K. James. Engr. Exp. Station, Univ. of Illinois, Bulletin No. 195.

This bulletin contains the results of tests made to study the value of the pottery-plaster method of determining stresses in structural and machine members due to external loads and to investigate the radial tensile stress in a curved beam.—M. B. R.

Instruments in the Modern Power Plant. H. M. Hammond. Engineering & Finance, November 1929, pages 254-259; December 1929, pages 303-306.

The November installment considers mechanically operated and electrically operated flow meters. The December issue discusses the Bailey boiler meter.

Developments of Interest to Metal Stamping Industry Featured at National Metal Exposition. Metal Stampings, October 1929, pages 771-774, 808.

Includes brief descriptions of testing machines and instruments.—M. S.

Many Interesting Developments at National Metal Exposition. Fuels & Furnaces, October 1929, pages 1551-1558.

Includes descriptions of industrial instruments.—M. S.

The Design and Operation of Vacuum Furnaces with Carbon Resistor Tubes. A. S. King. Preprint American Electrochemical Society, September 19-21, 1929, 14 pages.

Two types of electric vacuum furnaces are developed permitting the study of metallic vapors up to 3,500°C. Steady conditions of temperature and pressure are quickly reached, after which the light is permitted to pass to the spectrograph. An image of the interior of the tube is projected on the slit, light from the incandescent wall being excluded. The charge in the tube is vaporized and the characteristic radiations of the vapor excited under close control of conditions. A long column of uniformly heated vapor is obtained. Various spectroscopic studies are briefly described.—E. F.

SURVEYING & NAVIGATION

Crossing Rivers by Precision Leveling (Stromkreusung durch Feinnivellement) W. Borck. Zeitschrift fuer Vermessungswesen, August 15, 1929, pages 577-584.

The author discusses surveying problems across rivers and harbors as met in the City of Hamburg.—E. F.

Notable Progress in Surveying Instruments. William Bowie. Scientific Monthly, Nov., 1929, pages 402-406.

Article briefly sketches the tremendous strides made in surveying measurements during the last 250 years.—M. B. R.

Photogrammetric Determination of the Navigation Properties of Aircraft (Photogrammetrische Bestimmung der Navigationseigenschaften von Flugzeugen). E. V. Orel. Bild. u. Luftbild, June, 1929, pages 60-67.

Equipment and experiments with the dirigible ZR III.—E. F.

Stereo-Space Photographs and Stereo-Orthodiagraphy (Stereo-raumbild und Stereo-orthodiagraphie). Ing. Beyerlen. Bild. u. Luftbild, June 1929, pages 67-74.

Three groups of developing space photographs are considered.—E. F.

Contribution to the Theory of Photogrammetric Evaluation of Instruments (Zur Theorie photogrammetrischer Auswertgeraete). P. Gast. Allgemeine Vermessungs Nachrichten, April 24, 1929, pages 257-264.

The principle involved in the Stereautograph, Autokartograph, Aerokartograph and Stereoplanigraph is mathematically explained and illustrated by several figures.—E. F.

The Szuets Automatic Reduction Tachymeter (Das Szuets'sche selbsttaetige Reduktionstachymeter) Bildmessung & Luftbildwesen, September, 1929, pages 143-145.

The new devices involved in the automatic reduction tachymeter of Suess Nandor Rt, Budapest are described. The instruments can be used for numerical and graphical surveying methods.—E. F.

Influence of the Errors of the Sun Compass (Einwirkung der Fehler des Sonnenkompasses) G. A. Rune. Zeitschrift. fuer Vermessungswesen, November 1, 1929, pages 753-762.

Errors in reading of the common needle due to local disturbances of earth magnetism are responsible for the increased utilization of the sun compass. The adjustment of the latter is fully detailed and several practical examples are given.—E. F.

A New Coordinatograph (Ein neuer Koordinatograph) M. Wimmer. Allgemeine Vermessungs Nachrichten, October 30, 1929, pages 693-697.

The new apparatus is intended to replace straight edge, triangle, ruler or even transverse rule and compass.—E. F.

(Current Literature Review continued on Page 24)

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A New Inclinometer (Ein neuer Gefaellmesser) K. Luedemann. Allgemeine Vermessungs Nachrichten, August 28, 1929, pages 558-559.

After giving the main features of both groups of inclinometers, the writer discusses the new instrument for Gebrueder Wichmann m.b.H.—Berlin. The new portable apparatus is mainly constructed for the determination of height-and depth angles and permits an accuracy of ½' in horizontal measurements.—E. F.

Inspection Measurements With the Bosshardt-Zeiss Reduction Tachymeter (Pruefungsmessungen mit dem Bosshardt-Zeiss'chen Reduktionstachymeter) Dr. Walther. Allgemeine Vermessungs Nachrichten, September 25, 1929, pages 613-619.

After reviewing the publications on this instrument, the author discusses the 5 main sources of error in measurements, i. e. lighting, temperature, moisture, distance and declination.—E. F.

Nadir Triangulation (Nadirtriangulation.) J. Koppmair. Allgemeine Vermessungsnachrichten, January 16, 1929, pages 33-37; January 30, 1929, pages 65-73; February 6, 1929, pages 81-90; February 27, 1929, pages 146-154; March 13, 1929, pages 174; March 20, 1929, pages 182-190.

Definition, compensation of a pentagon and nadir-triangulation-series, influence of inclination of a plate, influence of altitude differences transferring of errors in nets of nadir triangles.—E. F.

The Magnet Theodolite of Weisbach Lingke (Der Magnettheodolit Weisbach-Lingke) K. Luedemann. Allgemeine Vermessungsnachrichten, January 16, 1929, pages 37-42.

One of the earliest magnet-theodolites is described. Includes bibliography.—E. F.

A Small Bussolen Tachymeter (Ein kleines Bussolentachymeter) K. Luedemann. Allgemeine Vermessungsnachrichten, March 27, 1929, pages 194-198; April 1929, pages 212-221.

Description and experimental results of a small tachymeter. Bibliography of 36 references.—E. F.

TIME, SPEED, ACCELERATION

Chronograph Registering One Six Millionth Second and Its Application to the Measure of the Irregularities of the Astronomical Pendulum. M. R. Lejay. Computes Rendus, April 22, 1929, pages 1089-1091.

The optical system of the instrument is described. The image from an oscillograph mirror is made to trace a helical path upon photographic paper wound on a cylinder. Abs.-Bull. Kodak Res. Labs.

An Electrical Speed Indicator. Elec. Rev., August 16, 1929, page 296.

Brief illustrated description of the "Wilkinson" speed indicator.—M. S.

Speed Indication, Greater Accuracy Claimed for Electrical Type Instrument. Electrician, Sept. 6, 1929, page 273.

An electrical speed indicator manufactured by F. A. Wilkinson & Partners, Ltd. of Hatfield, Kerts, Eng., is illustrated. It comprises a small dynamo that generates a voltage directly proportional to its speed, connected to an indicating instrument by means of a cable. The indicator is of the dead-beat type and is calibrated in r.p.m. which may be read without the aid of a stopwatch. The generator is driven by means of a round belt or direct-connected to the device whose speed is to be measured.—W. H. B.

Speed Indicator and Frequency Meter. E. H. Greibach. Journal American Institute Electrical Engineers, Aug 1929, pages 633-634.

The design of a simple mechanical speed indicator, consisting of a rotating cup and a ball placed inside of the cup, is described and discussed. This speed indicator can be built to give precise indications through a range of 2 per cent of a given speed. The order of precision in reading is about 1/10 of 1 per cent. When driven positively by a synchronous motor, it can be used as an accurate frequency meter.

Time Measuring by Commercial Alternating Current With Controlled Frequency. J. Adams. Journal Optical Society, December, 1929, pages 384-386.

This paper deals with the maintenance of frequency from second to second by 2 utility companies. The variations of the actual-cycles per second from the nominal value were measured by reference to a standard pendulum with a half-period adjusted to 1.0000 ± 0.0002 sec. Results are given.

An Impulse, Tallying Device and Electric "Stopwatch." P. Klopsteg. Journal Optical Society, November, 1929, pages 345-349.

Instrument is described and some laboratory applications mentioned.

MICROSCOPY

Microscopy in Reflected Light (Mikroskopie in auffallendem Licht) F. Hauser. Umschau, October 7, 1929, pages 715-719.

The writer reviews the development of microscopy and presents numerous illustrations of modern instruments and photographs.—E. F.

Metallography Simplified for Practical Use in Shop. Appendix—Supplementing microscopic testing by other methods (concluded). E. Preuss, G. Berndt, and M. V. Schwartz. Iron Trade Review, August 8, 1929, pages 328-330.

Deals with determination of thermal expansion by means of the dilatometer, and outlines physical tests. Includes illustrations of the Heraeus and Rockwell dilatometers, and the M. von Schwartz drop hardness tester.—M. S.

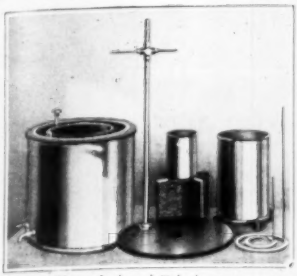
A Few Hints on Projection, Micro-Projection and Photomicrography. F. Hauser. Instrument World, November, 1929, pages 189-191.

Reprinted from "The Technical Instrument Bulletin" published by Emil Busch, A. G. The article reviews various apparatus for projection and micro-projection and gives a few suggestions on their use.

Metallographic Polishing. I. Automatic Metallographic Polishing Machine. S. Epstein & John P. Buckley. Journal of Research, November, 1929, pages 783-794.

An automatic metallographic polishing machine, designed particularly for studying polishing methods, but which should be useful in any metallographic laboratory, is described. The metal specimen is mounted in a metal ring and held in an arm which moves it back and forth along a radius of the turning polishing disk. At the same time the specimen is rotated. There are three arms to a disk, so that three times as many specimens as there are disks in the machine can be polished at a time. A high quality polish, free from pitting and scratches, is obtained. An outline of the proposed study of polishing methods is given.

(*Current Literature Review continued on Page 26*)



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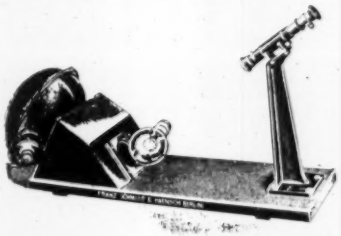

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A Vertical Optical Bench. M. A. R. Khan. Journal Scientific Instruments, October, 1929, pages 320-322.

An apparatus has been designed to measure accurately and conveniently the refractive index of small quantities of liquids and the focal-length of mirrors and lenses, by the method of coincidence of object and image.—M. B. R.

Improved Paper Developed and New Sources of Fiber Investigated Through Federal Research. Commercial Standards Monthly, October 1929, pages 88-89.

Research developed that properties of paper are responsive to treatment. Microscopic methods of determining fiber are briefly described.

SPECIFIC GRAVITY, DENSITY, WEIGHT

Modern Methods of Ascertaining Specific Gravity. W. A. Benton. Chemistry & Industry, November 29, 1929, pages 1145-1152.

Paper read before the Birmingham and Midland Section of the Society of Chemical Industry. Modern methods of measuring density are reviewed. The measurement of density of solids and liquids is covered in detail, gases touched but slightly.—M. B. R.

Weighing Contrivances for Loading Locomotives with Coal (Wiegeeinrichtungen fuer Lokomotivbekohlung). K. Diehl. Organ fuer die Fortschritte des Eesenbahnwesens, March 15, 1929, pages 99-101.

The former measurements of coal by volume are more and more being substituted by weighing method. The different installations are given.—E. F.

Weighing with Light. F. A. Pearson. Scientific American, November 1929, pages 416-418.

An instrument called "Opacimeter" is used to determine the weight of paper in process of fabrication. It consists of a source of light, photo-electric cell and a Leeds & Northrup recorder.—M. B. R.

The Ranarex Apparatus as Gas Density Meter for Gases of Rapidly Varying Density (Der Ranarex-Apparat als Gasdichtemesser fuer Gase mit schnell veraenderlicher Dichte) A. E. G. Mitteilungen, October 1929, pages 673-674.

The usefulness of the Ranarex Apparatus for the measurements of gases of slight differences of density is proved by investigations. The result of the measurements depends on the pressure of the gases entering the apparatus. The sensitivity of the instrument is greater in case of gases with low density than in case of gases of high density. Quick reaction and remarkable accuracy give it a wide field of application.—E. F.

Some Notes on Weighing and Weighing Machines. F. H. Pooley. Chemistry & Industry, Nov. 29, 1929, pages 1152-1156.

The various factors entering into the choice of weighing machines: Product of the factory, location of the weighing machines; type of weighing machine most suitable for the location and work; general considerations; are discussed.—M. B. R.

MAGNETISM

A New Variable Standard of Electromagnetic Induction. P. Klopsteg. Journal Optical Society, December 1929, pages 367-370.

A simple instrument, for use in electrical arrangement for measuring magnetic flux with a ballistic galvanometer, is described.

Electromagnetic Testing for Mechanical Flaws in Steel Wire Ropes. T. F. Wall. Journal Institution Electrical Engineers, July 1929, pages 899-911.

The paper contains an account of an electromagnetic method of testing for mechanical flaws in wire ropes such as colliery winding ropes, the method comprising the use of a "search band of flux" in combination with a search coil system. In the introduction are detailed the advantages of the use of alternating as compared with direct current for the excitation of the magnet system. Section 1 describes the results of an experimental investigation of the penetration of magnetic flux in "locked coil" wire ropes, for a supply frequency of 50 to 20 cycles per second respectively. In Section 2 the effect of mechanical strain on magnetic permeability is considered, with special reference to a. c. excitation. In Section 3 the change in reluctance of the air space due to eccentricity of the rope in the magnet system is examined. Section 4 contains an account of the construction of the rope-testing magnet system, and the method of utilizing the search band of flux is explained. Section 5 contains the results of tests on a length of wire rope which was especially constructed for the purpose by Messrs. Latch and Batchelor, and in which a series of hidden flaws were incorporated. A complete rope-testing equipment constructed in accordance with the principles explained in this paper has been installed in one of the Carlton Main Co's. collieries in the South Yorkshire.

The Measurement of Magnetic Quantities. L. W. McKeehan. Journal Optical Society, October 1929, pages 213-242.

Includes 202 references. This article correlates the work of a very large number of workers in the field of magnetism.

Permeameters for Measurements Over Wide Temperature Ranges. G. A. Kelsall. Bell Laboratories Record, November 1929, pages 100-104.

This article describes a permeameter for testing the permeability of toroidal cores at small magnetizing forces. This method no longer requires winding a ring shaped core of magnetic material with the requisite number of turns, usually several hundred. With the new permeameter the winding consists of only a single turn made in 2 parts, with which the sample may be readily interlinked. Later this new instrument was adapted for measurements at elevated temperatures.

Precision Permeability Measurements on Straight Bars and Strips in the Region of High Permeabiltiy. C. E. Webb & L. H. Ford. Journal Institution Electrical Engineers, November 1929, pages 1392-1316.

The construction of a yoke apparatus to give magnetizing forces up to H = 3000 on straight samples 20 to 25 cm. long, and up to H = 5000 on samples 8 to 10 cm. long is described. The method of measuring the magnetizing force by means of search coils is used, and an examination is made of its applicability to strip and bar samples mounted in the yoke apparatus. It is found that below H = 15, large errors results from the leakage taking place along the length of specimen under test. The conditions for staisfactory compensation for this leakage are determined and the method is then shown to give good agreement with tests on rings of similar magnetic properties. In Part 2 the effect of stress in the magnetic specimen is considered. Stress may be caused by clamping in the case of bars or by windings on rings or strips of sheet material, and it is shown that such stress may have a very large effect on the results of magnetic measurements. A further source of error in test strip samples is found to be the reluctance between the strips. Conditions of testing to obviate both these sources of error are indicated.—M. B. R.

(Current Literature Review continued on Page 28)

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An Apparatus for the Measurement of Magnetic Susceptibility. W. Sucksmith. London, Edinburgh & Dublin Philosophical Magazine, August 1929, pages 158-165.

After briefly considering the existing apparatus and methods, the author describes a simple instrument admitting rapid measurement of magnetic susceptibilities. An accuracy of ½% is obtained on substances of moderate specific susceptibility, while for susceptibilities of the order for measurements can be made to 1% or ½ gram of material. The force experienced by a specimen in a non-homogeneous field produces a very small movement of the specimen, thus eliminating the necessity for a null method. The movement, which is directly proportional to the magnetic force, is magnified to a suitable value for observation. The method could be easily adapted to measurements of the large forces on paramagnetic substances at very low temperatures.—E. F.

X-RAY TESTING & EXAMINATION

The X-Ray Exhibition During the Roentgentagung in Vienna (Die Roentgenausstellung anlässlich der Roentgentagung in Wien) M. Zakovsky. Maschinenbau & Elektrotechnik, October 20, 1929, pages 913-919.

A detailed description of X-ray equipment exhibited during the XX. Meeting of the Deutsche Roentgen-Gesellschaft Vienna is given.—E. F.

Notes on Etching Tests and X-Ray Examination of Some Manganese Minerals. William V. Smith-eringale. Economic Geology, August 1929, pages 481-505.

The following article represents the laboratory study undertaken in connection with the field investigation of manganese occurrences in the Maritime Provinces, Canada. Complementary to the main text of this paper there is added a short review of a number of Housmannite occurrences, also there is included a summary of the mineralogy and occurrence of the maritime deposits and suggestions as to possible mode of transportation and deposition of the manganese in their details.

The Intensity of Reflection of X-Rays from Diamond. A. H. Armstrong. Physical Review, October 15, 1929, pages 1115-1121.

The article covers spectrometer measurements of fine diamond powder. Information on the scattering power is given.—M. B. R.

Application of X-Rays in the Classification of Fibrous Silicate Minerals Commonly Termed Asbestos. H. V. Anderson & G. L. Clark. Industrial & Engineering Chemistry, October 1929, pages 924-933.

Attention is called to the difficulty of classification of fibrous silicates by usual optical, physical and chemical methods, and a method is suggested whereby classification of these minerals is greatly enhanced by precision measurements of the identity period and proper interpretation of the X-ray diffraction patterns.—M. E. H.

The New Securo Safety Apparatus for X-Ray Installations (Der neue Securo-Sicherheitsapparat fuer Roentgenanlagen) E. Fritsch. Maschinenbau & Elektrotechnik, October 20, 1929, page 919.

A new safety device protecting persons, which operate with X-ray equipment, against high voltage is considered. The Securo-safety apparatus is brought on the market by the Elektrizitaetsgesellschaft "Sanitas"—Berlin.—E. F.

Ionisation-Spectrometer for Long-Wave X-Rays (Ionisations spektrometer fur langwellige Roentgenstrahlen). H. Kuhlenkrampf & W. Woernle. Physikalische Zeitschrift, September 1929, pages 551-554.

A description of an apparatus with an X-ray tube for 10,000 Volt and 30 to 50 milli-ampere with water-cooling system. The construction is given in detail, the apparatus is similar to a vacuum-spectrograph but the positions of X-ray tube and photographic plate is exchanged.—H. A.

Contribution to Technical Material Investigation by X-Rays (Beitrag zur technischen Materialuntersuchung mittels Roentgenstrahlen) M. Jona. Zeitschrift Oesterreichies Ingenieur & Architekten Verines, October 11, 1929, pages 427-428.

The author confines himself largely to the following problems: determination of gross structure, detection of changes in structure and corrosion of material. The influence of voltage is shown by practical data and required exposure times are assembled in a table.—E. F.

A Hot-Cathode X-Ray Tube for Use in Spectroscopy. C. J. Smith. Journal Scientific Instruments, August 1929, pages 251-153.

An X-ray tube of the demountable type is described. It is easily made and can easily be cleaned or a new filament inserted. The latter part of the paper deals with a device which has been found useful in cooling the high potential end of the tube.—M. B. R.

Twentieth Meeting of the German Roentgen Society (XX. Tagung der Deutschen Roentgen-Gesellschaft) Dr. Petertil. Maschinenbau & Elektrotechnik, October 20, 1929, pages 909-912.

The author reviews the following papers presented before the Deutsche Roentgengesellschaft, April 20-23, 1929, Vienna: (1) Halberstadt, "Setting of limiting load of modern "tubes" for diagnosis (Einstellen der Grenzbelastung von modernen Diagnostik-Roehren); (2) M. Jona, "Remarks on the economy of X-ray tubes shown on different types." (Bemerkungen zur Oekonomie der Roentgenroehre an verschiedenen Apparatetypen); (3) A. Bouwers, "A Metal X-ray tube with rotating anode," (Eine Metallroentgenroehre mit drehender Anode); (4) H. Vramer & A. Born, "The new irradiation apparatus for the utilization of the Metalix-tube for therapy," (Das neue Bestrahlungsgeraet fuer die Verwendung der Metalix-Therapierroehre); (5) R. Jaeger, "A new principle of measuring doses," (Ein neues Dosismesserprinzip, Kompensationsmethode); (6) S. Strauss, "The limit ray Mecapion and further improvements of the X-ray mecapion," (Das Grenzstrahl-Mekapion und weiters Verbesserungen am Roentgen-Mekapion); (7) H. Hermann, "Investigations with the pinhole camera," (Untersuchungen mit der Lochkamera); (8) H. Franke, "Ionimetric determinations of the most suitable exposure times," (Ionimetrische Bestimmung optimaler Belichtungszeiten); (9) C. Beyerlen, "Stereo-grametric problems and improvements in X-ray technique with particular regard to the relation between the distorted and the normal X-ray photograph of normal space lattice and a new Stereo camera for two tube operation" (Stereogrammetrische Fragen und Neuerungen in der Roentgentechnik, insbesondere die Beziehungen des verzerrten oder heteromorphen zum raumrichtigen oder tautomorphen Roentgenbildes und ein neues Stereo-Moment-Aufnahmegeraet mit Zweiroehrenbetrieb); (10) C. Fried, "A new irradiation apparatus in connection with the Metalix-tube for therapy" (Ein neues Bestrahlungsgeraet in Verbindung mit der Metal Therapierroehre.)—E. F.

X-Ray Inspection of Castings. Ancel St. John. Fuels & Furnaces, September 1929, pages 1371-1372, 1407-1408.

Discusses the value of X-ray inspection in the foundry. It can teach the foundryman how to make better castings, and can prove that individual castings are sound and are suitable for severe working conditions.—M. S.

(Current Literature Review continued on Page 30)

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Leeds & Northrup Co.

Temperature-Time
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Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Co.

Thermometer
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Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Wilson-Maeulen Company, Inc.

Thermostat
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
Taylor Instrument Companies
Westinghouse Elec. & Mfg. Co.

Thickness
H. Z. Schniewind

Time
Brown Instrument Co.
Foxboro Co.
Stromberg Electric Co.
Tagliabue Mfg. Co., C. J.

Significance of X-Ray Analysis of Alkali Sulphates. A. E. H. Tutton. London, Edinburgh & Dublin Philosophical Magazine, August 1929, pages 195-201.

The full confirmation of the law of progression according to atomic number is afforded by X-ray analysis. Fifteen references of investigations mostly pertaining to the X-ray analysis and determination of dimensions of the unit cells of the space-lattices of alkali metallic salts are given.—E. F.

X-Ray Examination in the Shop (Roentgenuntersuchungen im Werkstaettenbetrieb) C. Kantner & A. Herr. Metallwirtschaft, June 14, 1929, pages 575-578; June 21, 1929, pages 602-606.

The utilization of X-rays for the purpose of determining the presence of defects, inhomogeneities and the gross structure of materials is described and the value of the radiographic method of inspection is fully outlined by several practical examples. The carrying out of the method for radiological diagnosis is thoroughly explained and a more recent advance, the application of stereoscopic radiography, is discussed ascertaining depth and angular disposition of inhomogeneities. The problems of the shop solved up to the present by X-ray radiography are summarized, the economic limits considered and two calculations given with the object of X-ray testing destined for every shop use and not scientific work.—E. F.

PHYSICAL TESTING

New Results in the Field of Wear Research (Neue Ergebnisse auf dem Gebeit der Verschleissforschung) M. Fink. Organ fuer die Fortschritte des Eisenbahnwesens, October 15, 1929, pages 405-412.

The article treats of the well-known phenomenon that in wear experiments, particularly those conducted under rolling friction, an oxidised wear dust is formed. Investigations are carried out in oxygen-free gases which, in contrast with former conceptions, proved that this phenomenon does not represent a secondary occurance but is a main component in wear process. The oxidation component furthermore plays a certain role in the formation of the rail grooves. The investigations were carried out with an Amsler Testing Machine using steels with various C-content, V2A-steel and copper.—E. F.

Modern Methods of Physical Testing (Die Verfahren der neuzeitigen mechanischen Werkstoffpruefung). Dr. M. Moser. Glasers Annalen, Feb. 1, 1929, pages 34-40.

The paper which includes 44 illustrations, was presented at the Deutsche Maschinentechnische Tagung, October 16, 1928, Berlin. It reviews static and dynamic testing methods, methods with constant and altering direction of strain, fatigue tests and results.—E. F.

Modern Methods of Physical Testing (Die Verfahren der neuzeitigen mechanischen Werkstoffpruefung). Dr. Kuehnel, Dr. Lehr & Dr. Fuechsel. Glasers Annalen., March 15, 1929, pages 88-93.

A critical discussion of the testing methods and their application in construction and shop in regard to tensile and bending strength, notched impact strength, static and dynamic reverse bending strength, hardness and resistance to wear.—E. F.

Modern Testing Machines for Structural Material (Neuzeitliche Baustoffpruefmaschinen) F. Franks. Zeitschrift Oesterreichischen Ingenieur & Architekten Vereines, October 11, 1929, pages 424-428.

Methods and machines for testing various properties of structural materials are illustrated, reviewed and critically discussed.—E. F.

Material Testing for Control of Concrete Construction (Materialpruefungen im Rahmen der Baukontrolle bei Betonbauten) E. Kissel. Beton & Eissen, October 20, 1929, pages 381-386.

The paper which contains 44 references reviews all testing methods applied to concrete construction work.—E. F.

New Testing Machines for Investigation of Material Under Alternating Often Repeated Bending Stress (Eine neue Pruefmaschine zur Untersuchung der Werkstoffe bei wechselnden, oftmals wiederholten Biegebeanspruchungen) E. Dorgerloh. Metallwirtschaft, October 7, 1929, pages 986-990.

After a brief classification of fatigue testing machines, the author introduces a new apparatus which was constructed and developed in the Institute fuer Metallurgie und Werkstoffkunde at the Technische Hochschule Dresden. The test bar is mounted vertically, clamped at one end and stressed at the other, free end. The testing machine is electrically driven at 3000 rpm. A circuit breaking device stops the motor and testing machine after fracture occurred. The original paper which is well illustrated, must be consulted for further details of the devices involved in the construction.—E. F.

Critical Notch Impact Values (Kritische Kerbzähigkeitswerte) W. Kuntze. Metallwirtschaft, October 7, 1929, pages 992-998; October 18, 1929, pages 1011-1017.

The writer critically discusses the influence of sample machine temperature and material upon the magnitude of the determined impact values. A certain range occurs in which a break of impact strength takes place due to several known influences which however do not yield satisfactory explanations and conclusions in regard to the behavior of the material. The author believes, based on a wealth of investigations that 2 factors mainly exert a dominating influence: (a) the resistance to deformation, which is dependent on shape, material, velocity and temperature and (b) the separation strength or "Trennfestigkeit" which only depends on the material, i. e. on the working during stress. Since the impact test and the comparison of data is a rather complicated subject, the author does not only propose whole sets instead of single tests but urges standard methods. In case of limited tests the relationship between impact value and necking of the statically tested tensile bar must be involved in the measurement. On account of a large set of experiments, the author establishes that necking of the compression zone of the sample is necessary. The detection of the breaking range by means of an accelerated test is given. The paper contains 23 illustrations and 38 references.—E. F.

Recent Physical Testing Machines (Moderne Materialpruefmaschinen) F. Bruckner. Zeitschrift Oesterreichischen Ingenieur & Architikten Vereines, October 11, 1929, pages 428-429.

The testing machines for wires, sheets, ropes, lumber and cast iron, and for concrete are discussed.—E. F.

The Torsion Test (Der Verdrehungsversuch) Fr. Meyer. Siemens Zeitschrift, August 1929, pages 496-499.

Testing of torsion, static and dynamic, is discussed. Formulae, calibration and performance of the tests are given. The rotation-vibration testing machine of Foeppl-Busemann is especially considered.—E. F.

(Current Literature Review continued on Page 32)

BUYER'S GUIDE

Vacuum
Brown Instrument Co.
Foxboro Co.
Unit Heater Valve—Motor Operated
American Radiator Company
Bristol Company
Brown Instrument Co.
Charles Engelhard, Inc.
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Bristol Company
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DENSOMETERS
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DRAFT GAGES—see Gages

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Recording
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Standards
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FUEL FLOW INDICATOR
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Brown Instrument Co.
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Leeds & Northrup Co.

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Brown Instrument Co.
Foxboro Co.

GASOMETERS
American Meter Co.

GAGE RODS
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GAGES
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Cylinder
B. C. Ames Co.
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B. C. Ames Co.
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Pump
Tagliabue Mfg. Co., C. J.

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GREASE TESTING APPARATUS
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Rubicon Company
Westinghouse Elec. & Mfg. Co.
Weston Electric Inst. Corp.

GROUND-OHMER
Leeds & Northrup Co.
Herman H. Sticht & Company

Compressive Strength of Clay Brick Walls. A. H. Stang, D. E. Parsons, & J. W. McBurney. Journal of Research, October 1929, pages 507-571.

Compressive tests of 168 walls of common brick, each 6 feet long and about 9 feet high and of 129 wallettes, about 18 inches long and 34 inches high, were made. Four kinds of brick, 3 mortar mixtures, 2 grades of workmanship, different curing conditions, and 10 different types of masonry (3 solid and 7 hollow) were the variables.

A New Index to Control Cable Endurance. T. Ogawa & S. Suzuki. Report No. 49. Aeronautical Research Institute, Tokyo Imperial University, September 1929, pages 244-256.

In this report are described the methods for reading the number of bends corresponding to the first few fractures of the component wire and the effects, of the diameter of the pulley and the magnitude of tensile stress upon the endurance of the control cable.—M. B. R.

Physical and Mechanical Properties of Portland Cements and Concretes. W. Hatt & R. Mills. Engg. Exp. Station, Purdue University, Bull. 34, 99 pages.

This bulletin investigated the effect of temperature reinforcement in adding to the toughness of concrete and shows that small amounts of such reinforcement will add to the extensibility of the concrete, that is, its ability to undergo deformations without surface checking.—M. B. R.

Bend Testing of Sheet Metals to Determine Their Drawing Qualities. J. R. Townsend, W. A. Straw, & C. H. Davis. Metal Stampings, October 1929, page 802.

Abstract of paper presented at annual meeting of the American Society for Testing Materials. The machine employed has a motor drive and accurately prepared and aligned jaws, and is an improvement on the Amsler bend test machine.—M. S.

Relation Between Pressure and Diameter of Impression in Brinell Hardness Test. Kinnosuke Takahasi. Metal Stampings, November 1929, pages 888-908.

Abstract from Tohoku Imperial University Science Reports. Meyer found the relation $P = ad^n$ where P is the pressure, d, the diameter of indentation and a and n are constants characteristic of the substance. Author studied this relation for small pressures from 5 to 100 kg. Used a 5-ton Amsler tensile testing machine to which a 10 mm. Brinell ball was attached, and aluminum copper, zinc, brass, and carbon steel specimens. Found that a and n are not constant for entire range of pressures, but decrease with pressure. Value of n tends to equal 2 as the load decreases, and this is the limiting value in the case of plastic deformation. It is 3 in the case of elastic deformation.—M. S.

LIGHT, COLOR, VIBRATION, SOUND

A New Quartz Spectrograph. H. F. Kurtz. Journal Optical Society, December 1929, pages 378-383.

This instrument, manufactured by Bausch & Lomb Optical Company, is described.

Some Light Reflecting Properties of Flowers and Foliage. S. G. Hibben. Transactions Illuminating Engineering Society, October 1929, pages 752-769.

The paper covers tests of some typical flora, especially the spectrophotometric investigations of flower petals, and gives the technical picture of flower colors. Spectral studies are made of the changing colors of autumn foliage and graphs plotted of representative trees to depict their increasing reflecting properties and their autumnal color characteristics.—M. B. R.

An Electromagnetic Monochord for the Measurement of Audio Frequencies. J. H. Owen Harries. Proceedings Institute Radio Engrs., August 1929, pages 1316-1321.

The desirable properties for an instrument for measuring frequencies over the audible range are briefly mentioned and a suggested electrically excited monochord is considered. In practice certain difficulties are found and lead to a proposal for employing the harmonic modes of vibration of the stretched wire. The theory of this is given, as well as the relation between the frequency response and the position of a movable bridge. The constructional details and the method of calibration from a single turning fork are described in turn. Miscellaneous considerations concerning the practical operation conclude the paper.

Spectrophotometry in the Ultra-Violet. F. H. Gage. Journal Scinetific Instruments, August 1929, pages 256-258.

A simple apparatus is described for the determination of the absorption of ultra-violet light by solutions, providing for the rapid interchange of two cells containing respectively the solution and pure solvent. Spectrum photographs are taken alternately (a) through the solvent, with the intensity reduced to a known extent by a rotating sector, (b) through the solution at full intensity.—M. B. R.

Variations in the Spectrum of the Light Emitted by Quartz Mercury Lamps. Tokue Takahashi & L. H. Clark. Journal Scientific Instruments, September 1929, pages 273-277.

The spectra of the radiation emitted by mercury in common use have been studied. Variations in the distribution of intensity in the spectra have been observed and traced to irregularities in the quartz envelopes of the lamps. A mercury lamp provided with a plane quartz window has been made which removes this defect and is advocated for spectroscopic measurements.—M. B. R.

Instruments and Methods Used for Measuring Spectral Light Instensities. G. R. Harrison. Journal Optical Society, November 1929, pages 267-316.

A summary on this subject. Contains 88 references.

A New Photometer Head. A. H. Pfund. Journal Optical Society, December 1929, pages 387-389.

This article describes the possibility of making a perfect photometric edge.

Measurements of the Velocity of Light. Science, May 17, 1929, pages X-XII.

A description of Prof. Michelson's latest work. Abs. Bull. Kodak Res. Labs.

The Comparison of the Whiteness of Fabrics, Using a Cube Photometer. A. Adderley. Instrument World, October 1929, pages 157-160.

This article is the first portion of a paper published in the Journal of the Textile Institute, August 1929. The instrument, which measures the whiteness and luster of a fabric and enables 2 samples to be accurately compared, is described.—M. B. R.

The Color in Photography With Particular Reference to Photogrammetry (Die Farbe in der Photographie unter Berueeksichtigung der Photogrammetrie) F. Leiber. Bildmessung & Luftbildwesen, September 1929, pages 137-143.

The paper presented before the Deutsche Gesellschaft fuer Photogrammetrie, May 1929, Berlin, gives in diagrams and photographs taken with and without filters the effect of color in photography and particularly refers to birds eye view snapshots.—E. F.

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BUYER'S GUIDE

GYPSUM TESTING INSTRUMENTS
H. Z. Schniewind
HARDNESS TESTERS
Akatos, Inc.
Industrial App. & Inst. Co.
H. Z. Schniewind
Wilson-Maeulen Company, Inc.
HARMONIC ANALYZERS
Leeds & Northrup Co.
HELIOSTATS
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HIGH FREQUENCY APPARATUS
Argeo Laboratories, Inc.
HIGH VOLTAGE
Indicators
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Testing Devices
Westinghouse Elec. & Mfg. Co.
HUMIDITY CONTROLLERS
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HUMIDITY RECORDERS
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Leeds & Northrup Co.
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Taylor Instrument Companies
HYDROGEN ION METERS
Indicating
Leeds & Northrup Co.
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HYDROMETERS
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HYGROMETERS
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IMPACT TESTING MACHINES
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General Radio Co.
Leeds & Northrup Co.
Rubicon Company
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Foxboro Co.
KLYDONOGRAPHS
Westinghouse Elec. & Mfg. Co.
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Gaertner Scientific Corp.
H. Z. Schniewind
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Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Enginerr's, Wye, Precision
Prism
Taylor Instrument Companies
LIME TESTING INSTRUMENTS
American Instrument Company
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LUSTER METERS
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Herman H. Sticht and Company
MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.
MELTING POINT APPARATUS
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METER TESTERS, Gas
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MICROMETERS
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MICROAMMETERS
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Wilson-Maeulen Company, Inc.
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General Radio Co.
Jewell Electrical Instrument Co.
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Rubicon Company
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Spencer Lens Co.
Petrographical
Akatos, Inc.
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Spencer Lens Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Industrial App. & Inst. Co.
Spencer Lens Co.
MICROTOMES
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Spencer Lens Co.
MILLIAMMETERS
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General Radio Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.
MILLIVOLTMETERS
Bristol Company
Charles Engelhard, Inc.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Taylor Instrument Companies
Weston Electrical Inst. Corp.
Wilson-Maeulen Company, Inc.
MOTION RECORDERS
Mechanical
Bristol Company
MULTIMETERS
Rawson Electrical Instrument Co.
MULTIPLIERS
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Weston Electrical Inst. Corp.
NEON FILLED TUBES
Argeo Laboratories, Inc.
NEPHELOMETERS
Akatos, Inc.
OHM METERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Herman H. Sticht and Company
Weston Electrical Inst. Corp.
OIL TESTING APPARATUS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
OIL TESTING EQUIPMENT
OPERATION RECORDERS
Electrical
Bristol Company
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Brown Instrument Co.
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OSCILLOGRAPHS
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Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
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Gaertner Scientific Corp.
PERFORMANCE METER
PERMEAMETERS
Leeds & Northrup Co.
Rubicon Company
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Spencer Lens Co.
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Gaertner Scientific Corp.
PHASE INDICATOR
Westinghouse Elec. & Mfg. Co.
PHASE SEQUENCE INDICATOR
Herman H. Sticht Co.
PHOTO-ELECTRIC CELLS
Argeo Laboratories, Inc.
PHOTOMETERS
Akatos, Inc.
American Meter Co.
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.
Industrial App. & Inst. Co.
Leeds & Northrup Co.

ELECTRICITY

Use of the Thermionic Valve in Measurements of Ionization Currents. J. Teegan. Nature, July 20, 1929, pages 91-92.

A simple method of recording on a unipivot galvanometer currents of the order of 10^{-} amp. Abs. Bull. Kodak Res. Labs.

Watt-Hour Meters Checked by Selenium Cell. H. R. Richardson. Electrical World, October 5, 1929, page 680.

A light-sensitive cell affords an automatic recording of meter revolutions. The arrangement of the meters and apparatus except the chronograph and the standard wattmeter with load control is illustrated. The meter is set with the cover removed and a lamp with condensing lens is mounted above to permit direction of a beam of light through one of the anti-creep holes in the disc. Below the disc the selenium cell is mounted in a case cutting off excess rays of light. The light flash resulting each time the anti-creep holes pass the light beam is reduced to one per revolution of the meter by covering one hole with black varnish. In the installation at the research bureau laboratory of the Brooklyn Edison Co., Inc., the vacuum selenium type cell is connected in series with a resistance of about 10,000 ohms and a single cell dry battery. The change in drop across the resistance is used as an input to the amplifier which gives a change of up to 80 millamperes in output current. This operates a standard telegraph relay which transmits an impulse to a chronograph pen. A second pen gives a reference marking of 1 sec. intervals controlled by the laboratory standard clock.—W. H. B.

Recent Developments in Electricity Meters, with Particular Reference to Those for Special Purposes. J. L. Carr. Journal Institute Electrical Engineers, July 1929, pages 859-898.

The paper gives a general survey of metering work in England. Some particulars are given regarding the more usual faults found in Seivere, and the requirements for maintained accuracy are briefly discussed. Various standard types of meters are examined and recent modifications detailed. Methods used for obtaining summated demands and consumption are discussed together with various types of equipment for special purposes. The development for reactive K. V. A. metering methods is traced and apparatus described. The testing of such apparatus is difficult and calls for a high degree of skill. Finally a few remarks are made regarding special tariffs and testing procedure.

"Bridge-Meg" Tester, Portable Testing Set for Measuring Insulation and Conductor Resistances. Electrical World, September 6, 1929, page 281.

The "Bridge-Meg" resistance tester manufactured by Evershed & Vignoles, Ltd., Acton Lane, Chiewick, Eng., permits a change to be made from the "Meg" setting, used for testing insulation to the "Bridge" setting used for measuring low resistances, by a turn of the change-over switch without altering external connections. The new set is a combined ohmmeter and generator built into one case with a set of adjustable resistances and by the turn of a single switch it serves for measuring high resistances or for determining conductor resistances by the Wheatstone bridge method.—W. H. B.

A New Testing Set. Electrical Review, September 6, 1929, pages 415-416.

Describes the "Bridge-Meg" resistance tester of Evershed & Vignoles, Ltd. This is a combined ohmmeter and generator of the "Meg" type, built into one case with a set of adjustable resistances.—M. S.

Studies in the Measurement of Electromotive Force in Dilute Aqueous Solutions. I. A. Study of the Lead Electrode. Walter R. Carmedy. Journal American Chemical Society, October, 1929, pages 2905-2909.

A new method of e. m. f. measurement in dilute solutions is described. From the results of the measurements made with the cell: Pb (Hg), $PbC2_2$, AgCl, Ag, the normal electrode potential of lead and the activity coefficients of lead chloride have been calculated.—M. E. H.

Control of Protection and Measuring Installations (Kontrollmessungen an Schutz-und Messeinrichtungen). O. Zwierina. Maschinenbau & Electrotechnik Wein, September 8, 1929, pages 787-791.

The Testing of Porcelain Insulators. B. L. Goodlet. Journal Institute Electrical Engineers, October 1929, pages 1177-1212.

Includes discussion. Paper covers the technique of porcelain insulator testing, including the usual electrical and mechanical tests called for in the various British specifications, and also special tests of more recent origin.—M. B. R.

Cell-Testing Instruments. Electrical Review, August 16, 1929, page 295.

Brief illustrated descriptions of the "Hoyt" cadmium battery cell tester and of the "Ferranti" cell-testing voltmeter.—M. S.

Electric Current Measurement in Terms of Length, Mass, and Time. T. B. Brown. Journal Optical Society, November 1929, pages 320-325.

The experiment consists of two parts: In part I the magnetic field produced by electric current flowing in a modified Helmholtz coil is balanced against the field of a permanent bar magnet. In part II this same magnet is swung at the center of the coil as a magnetic pendulum. From these observations, made in terms of length, mass, and time only, both the strength of the current and the magnetic moment of the magnet may be computed. Inaccuracy due to an unsteady local "earth's field" is minimized, and a relatively high precision results.

Note on the Theory of Screened Impedances in A. C. Bridges with the Wagner Earth. A. C. Bartlett. Journal Scientific Instruments, September 1929, pages 277-280.

This note is based on an important paper by Hartshorn & Wilmotte (Journal Scientific Instruments, November 1926) and puts forward a simple explanation of the action of shielded impedences.—M. B. R.

Types and Applications of the Linker-Switch for A. C. Measurements (Ausfuehrungsarten und Anwendungsgebiete des Linger-Messschalters fuer Wechselstrommessungen). B. Duschnitz. Elektrotechnische Zeitschrift, August 1929, pages 1228-1230.

The Linker-switch is made of a rotating cylinder of insulating material on which four or more metallic sections are arranged in a manner described in detail and to which six or more brushes are connected. In this way it is possible to measure energies in delta-connected three phase systems with or without neutral wire with only one wattmeter, one ammeter and one voltmeter and measurements of currents in two three or more branches of single or three-phase systems, especially if current transformers are used, without interruption of the service by simply switching over of only one ammeter. The Linker-switch is built in 29 sizes, covering voltages up to 6000 volts and currents up to 2000 amps.—H. A.

(*Current Literature Review continued on Page 36*)

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A Vacuum Tube Impedance Bridge. G. A. Stone. Journal Optical Society, November 1929, pages 326-334.

A vacuum tube impedance bridge is described. Before using the bridge for measuring unknown inductance or capacitance, it is necessary to determine the impedance of a standard capacitance or inductance. When once this frequency has been determined, it may be used in any subsequent measurements of these quantities.

A Vacuum Tube Voltage Regulator for Large Power Units. L. C. Verman & H. J. Reich. Journal Optical Society, October 1929, pages 243-249.

Describes and illustrates this apparatus.

The Development of Electrical Remote Measurement (Die Entwicklung der elektrischen Fernmessung). G. Keinath. Electrotechnische Zeitschrift, October 17, 1929, pages 1509-1514.

In this paper read before the Elektrotechnische Verein the development of remote control as used for measuring over long distances, for recording of instrument indications, summation of indications, and multiple measuring, is discussed, and the different methods used in European and American practice described. The requirements for an installation of remote control are stated. The impulse methods are of greatest importance because they are not influenced by the state of the lines. Connection diagrams are given for method of remote summation and a description of a large remote control installation of the Berlin Electric Works is given.—H. A.

The Aperiodic Amplifier in the Measuring Science (Der aperiodische Verstaerker in der Messtechnik). M. von Ardenne. Electrotechnische Zeitschrift, November 7, 1929, pages 1617-1620.

The sensitivity of electrical measuring instruments is limited. It has been tried for some time to utilize the amplifying effect of electron tubes in order to lower the measuring limit. The excellent suitability of amplifiers with resistance coupling and multiple tubes for the measurement of high and low frequency potentials is pointed out and the correct arrangement of such amplifier is described on hand of a model. Special emphasis is laid on an arrangement combining a measuring amplifier for high frequency with a tube voltmeter; this combination permits the measurement of high-frequency voltages as low as one hundred-thousandth of a volt. Another combination consisting of measuring-amplifier with a Brown's tube is discussed.—H. A.

Inductances of High Permanence. W. H. F. Griffiths. Journal Scientific Instruments, November 1929, pages 354-357.

The design of inductances for use in substandard wave-meters and for other radio-frequency purposes is discussed and suitable inductances are described.—M. B. R.

Measurement of Frequency. S. Jimbo. Proceedings Institute Radio Engineers, November 1929, pages 2011-2033.

Various methods of absolute measurement of frequency are first described. Particular attention is devoted to the stroboscopic method and the phonic motor method for audio frequencies. A modified method of harmonic comparison is also presented. The author designed a clock-controlled oscillator which consists of a tube-driven 25 cycle adjustable tuning fork and a chronometer. The performances of various kinds of tuning fork oscillators are discussed mathematically, and a new type, which has a magnetic device of such nature as to make the electromagnetic controlling force extremely small, is described. The factors affecting the constancy of frequency of quartz oscillators are discussed. Several types of electrical and mechanical resonator are compared with respect to their usefulness as frequency standards.—M. B. R.

Notes on Standard Inductances for Wavemeters and Other Radio Frequency Purposes. W. H. F. Griffiths. Experimental Wireless, October 1929, pages 543-549.

In this article are given methods of constructing inductances with a view to the elimination of sources of inconstancy of sub-standard wavemeter calibration which are attributable to these components of simple resonant circuits. Such sources of inconstancy have hitherto been unimportant but may now become appreciable owing to the reduction of other sources of inconstancy by recent improvements in variable condenser design. In addition to inconstancy due to age, lack of ruggedness and temperature-coefficient, that due to changes of self-capacity and effective resistance with variation of humidity is considered.—M. B. R.

New A. E. G. Alternating Current Meters Type J6E andJ6. (Neuer AEG-Wechselstromzaehler Form J6E und J6) AEG-Mitteilungen, November 1929, pages 737-740.

The AEG-alternating current meter type JE is improved. The new designs have the type designation J6E and J6 respectively. The construction and the characteristics of these new instruments is explained by means of characteristic curves and photographs.—E. F.

The Use of the Quadrant Electrometer as a Ballistic Energy Meter. P. D. Morgan & S. Whitehead. Journal Scientific Instruments, August 1929, pages 241-247.

This paper describes how the quadrant electrometer may be employed as a ballistic energy meter. The theory of the method is given by which its performance as a ballistic instrument may be predetermined from a knowledge of its periodic time and sensitivity as a voltmeter. Test results are given showing that results calculated from the theory are in excellent agreement with experiment. The quadrant electrometer used in this way may be employed for recording the energy released during very short time intervals, such as when a fusible cut-out or circuit breaker operates under short circuit conditions. The method given is applicable to either A. C. or d. c. circuits, and has given satisfactory results in the Test House of the Electrical Research Association where it has been in use during the last 3 years.—M. B. R.

A Method of Increasing the Sensibility of the Dolezalek Type Electrometer; and a Direct Reading "Null" Circuit. J. M. Pearson. Journal Optical Society, December 1929, pages 371-377.

In connection with some studies being made on the scattering of electrons by gases, we have found ourselves in need of a means of measuring currents over a range of several orders of magnitudes. The method developed below has been found so satisfactory and convenient, that it is thought, perhaps, to be of general interest.

The scheme makes use of a Dolesalek electrometer, of comparatively rugged construction, which has been slightly modified to increase its sensibility. This instrument is used as an element in a null circuit that is direct reading, and that can be adjusted electrically to cover a wide range of orders of magnitude of current.

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LIQUIDS

Water Level Measurement on Hydrostatic Principles (Wasserstandmessung auf hydrostatischer Grundlage) M. Shaack & H. Lohmann. Siemens Zeitschrift, October 1929, pages 604-612.

The introduction contains the various measurements of level lines of water. The authors then consider in detail hydrostatic measurement, i. e. by means of the pressure differences of two water columns, one of which is held constant, while the other represents the depth of water in any container, tank, reservoir, etc. This discussion includes the theoretical principles and formulae involved in the hydrostatic measurement, investigations and results collected in diagrams and tables, and practical applications.—E. F.

Improvements of Watermeters (Neuerungen an Wassermessern). Obering Bock. Gas Wasserfach, June 8, 1929, pages 569-572.

This abundantly illustrated paper fully outlines the latest improvements in the construction of watermeters.—E. F.

Device for Maintaining a Constant Rate of Flow of Liquids. John D. Sullivan. Industrial and Engineering Chemistry, Analytical Division, October 15, 1929, page 233.

A simple, easily constructed device for siphoning off wash liquids at a slow rate.—M. E. H.

Electric Velocity-Meter for Liquids (Elektrisch Geschwindigkeitsmesser fuer Fluessigkeiten). P. Dupin. Elektrotechnische Zeitschrift, October 1929, page 1514.

The apparatus is based on the change of wave-lengths of an oscillating circuit by changing its capacity or inductance. An orifice plate is placed in the flow to which one metallic side of a cylindrical condenser is rigidly connected. The movement of the orifice plate changes the capacity of the condenser which is in series with the condenser of a small tube-sender. The changes of frequency are made audible. The instrument is calibrated by a water current whose velocity is first measured exactly in another way. The calibration curve is a straight line which is an advantage compared with the pitot tube. From Genie Civil, Vol. 94, page 220.—H. A.

Innovations in the Construction of Motor Water Meters (Neuerungen im Bau motorischer Wassermesser) G. Eggers. Siemens Zeitschrift September 1929, pages 576-580; October 1929 pages 612-617.

The author considers in his abundantly illustrated paper the more recent perfections of water meters and mainly discusses the following types: Protos water meter for operations in either direction and "dry" and "wet". Woltmann water meter of various constructions, and water meter combinations. Water meters for domestic purposes including test and control meters as well the layout of water testing stations are given.—E. F.

Overflow Type Juice Level Regulator for Evaporators. G. H. W. Barnhart. Facts about Sugar, November 9, 1929, pages 1070-1073.

A description of its operation with a discussion of theoretical operating data.—M. B. R.

GASES, AIR & STEAM

Pressure Considerations and Linear Conversions of Steam, Air and Gas Meters. (Druckberuecksichtigung und Linearuebersetzung an Dampf-, Luft-und Gasmessern.) H. Hoffmann. Messtechnik, October 22, 1929, pages 271-274.

This article discusses the necessary for making corrections for pressure, and gives the values of the errors if this is not done. The influence of the fall off of the pressure on the errors is considered. Various measuring methods are considered: mercury differential manometer with parabolic shaped ring balance; electrical methods.

Measurements of Ventilation Currents (Messungen an Wetterstroemen). E. Stach. Glueckauf, April 20, 1929, pages 525-535; April 27, 1929, pages 557-565.

The author reports in detail on the progress concerning measuring instruments mainly sychrometer, hypsometer, stratoscopes and anenometers and their qualification for mining purposes. Accomplishment of measurements, survey of atmospheric pressure, temperature and moisture parallel with outside conditions. Mounting, attendance and reading of the instruments. Substitution of difficult formulae by graphical representation. Results obtained during a period of several years. Paper contains 22 illustrations and discussion.—E. F.

Gas Measuring Instruments and Regulators (Massinstrumente der Gastechnik und Regler). F. Schuster. Gas Wasserfach, June 8, 1929, pages 558-562.

The article reviews the gas measuring instruments which were exhibited on the Deutsche Ausstellung Gas und Wasser, Berlin, 1929.—E. F.

A Small Stack Gas Tester (Ein kleiner Rauchgaspruefer). A. Gross. Gas Wasserfach, May 18, 1929, pages 479-480.

The stack-gas-tester "Sicius" replaced by the simplified and improved "Carboscope," mainly by the substitution of the former liquid manometer by a diaphragm pressure gage. The principle of the carboscope represents an absorption of the CO_2 in an absorbent after which the pressure reduction indicates the content of CO_2 in the waste gas.

Apparatus for Technical Gas Analysis (Apparat fuer technische Gasanalyse). O. Burkhardt. Gas Wasserfach, May 25, 1929, pages 504-505.

The improved Greiner Apparatus for gas analysis which represents a modified Orsat, its operation and advantages are stated in detail.—E. F.

The Pressure Loss Curve as a Base for the Construction of Dry Gas Meter (Die Druckverlustkurve als Unterlage zur Konstruktion trockner Gasmesser). W. Marx. Gas Wasserfach, June 22, 1929, pages 626-630.

In addition to the measurement errors and the passing volume, the pressure losses determine the critical characteristic of gas meters. The influence of the pressure losses in relation to the passing volume is given by formulae and means are indicated for obtaining curves of pressure losses by means of the pressure oscillograph and conclusions from those curves in regard to the construction of gas meter are derived.—E. F.

Measurement of Large Quantities of Gas (Messung grosser Gasmengen). S. Erk. Zeitschrift, Instrumentenkunde, September 1929, pages 465-467.

Treats of the standard German apparatus for measuring large quantities of gas with particular regard t orecent development.—E. F.

The Measurement of Coke Oven Gas. (Die Mengenmessung von Kokereigas). P. Rheinlaender. Archiv fuer Eisenhuettenwesen, October 1929, pages 267-276.

The points covered are: basis of the measurement; dimensions, operating values and prices of station meters; accuracy of measurement; auxiliary measurements; arrangement and operation of a gas measuring station; calibration of station gas meters. Volume meters and flow meters are compared.

(Current Literature Review continued on Page 42)

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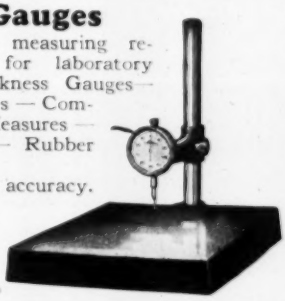

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Stromberg Electric Co., 233 West Erie Street, Chicago, Ill. 6
Stylograph Co., Coldwater, Rochester, N. Y. 37

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Tagliabue Mfg. Co., C. J., 18 to 99 Thirty-third St., Brooklyn, N. Y. Inside Front Cover
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Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. 2
Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J. 21
Wilson-Maeulen Co., 387 Concord Ave., New York, N. Y. 16

Air Flow Through Suction Valve of Conical Seat. Part I, Experimental Research. K. Tayaka, Report No. 50, Aeronautical Research Institute, Tokyo Imperial University, October 1929, pages 259-360.

This paper deals with the experimental work and its analytical investigation of the air flow through a conical seat suction valve.—M. B. R.

Exchange of Experiences regarding Commercial Gas Indicators and Leak Indicators. (Erfahrungsaustausch ueber die in den Handel gebrachten Gasanzeiger und Gassucher) Ing. Rodde, Gas & Wasserfach, October 26, 1929, pages 1037-1045.

Paper at the 70th Annual Meeting of the Deutscher Verein von Gas und Wasserfachmaenner June 1929, Berlin. Besides the smelling method, the palladium-chloride strip was the standard test of searching for gases. After mentioning the odor illusion, slow gas concentration in rooms, odor concealing and semi-odors, the author outlines the further development of smelling apparatus (a) diffusion instruments including apparatus according to Strache Joens designated as "Gasoskop," "Rapid" and "Express," the instrument of Joens called "Cajo" and its modification "Gluckauf" of Vulkan, furthermore the Nellissen and Sewerin apparatus, (b) electrical instruments as those of Siemens & Halske and Dr. Boehme based on the principle of heat conduction, and the "Wetterlicht III" working with catalytic combustion. The paper concludes with (c) optical measurements as employed by the "Interferometer" of Zeiss-Jena, based on light refraction.—E. F.

TEMPERATURE & MOISTURE

New Forms of Dry and Wet Bulb Thermometers. A. McAdie. Science, August 16, 1929, pages 172-173.

A description of new forms of these instruments. Abs. Bull. Kodak Res. Labs.

Temperature Measurement with Optical Pyrometers (Zur Frage der Temperaturmessung mit optischen Pyrometern). P. Thor. Tonindustrie Zeitung, January 10, 1929, pages 42-44.

Discusses the application of optical pyrometer in brick kiln operation.—E. F.

A Thermo-Electric Surface Pyrometer. Electrical Review, August 23, 1929, page 336.

Illustrated description of the Paul Braun pyrometer.—M. S.

A New Method for Measuring the Temperature of Glowing Filaments (Eine neue Methode zur Bestimmung der Temperatur von Gluehfaden). K. Schlesinger. Annalen der Physik, 1929, vol. 2 No. 8, pages 933-975.

This method uses the frequency with which the filament oscillates by considering it as an expanded string. The theory is fully described, the relation of frequency to temperature can be determined exactly if the frequency in cold state and a certain building constant A is known. The latter can be determined experimentally by measuring the resistance characteristic of the filament in the dark ranges. The experimental part and the tests are then given in detail and discussed. The accuracy obtainable depends on the accuracy with which frequencies and resistances can be measured. In an appendix a modification and simplification of the method is described which makes it applicable for use in shop practice, i. e. for testing radio-tubes in quantity production.—H. A.

Correcting Engine Tests for Humidity. D. B. Brooks. Journal of Research, November 1929, pages 795-806.

Data obtained on a 6-cylinder automobile engine indicate a loss of engine power with increasing humidity proportional to the volumetric loss of oxygen content of the atmosphere. It is shown that power and fuel consumption may be corrected by substracting observed water vapor pressure from atmospheric pressure and using the result in place of barometric pressure in the usual correction formula. The humidity correction may be as large as that due to changes in barometric pressure.

Simple nomograms are presented for obtaining the humidity correction, both neat sea level and at higher altitudes. An appendix gives methods of computation of these nomograms.

The Automatic Regulation of Temperatures up to 699°C. by Means of a Platinum Resistance Regulator. E. A. Cooke & J. C. Swallow. Journal Scientific Instruments, September 1929, pages 287-293.

A method of temperature control for thermostats or air ovens depending on the change of electrical of temperature is described. Provided use is made of a suitable thermionic valve relay control of temperature is accurate to + 0.1 C. at 350 C. and to +0.2 C. at 699°C.—M. B. R.

A Design for a Humidity Slide Rule. George Forrest Davidson. Journal Scientific Instruments, October 1929, pages 318-320.

A slide rule is described, by means of which the dew-point, the pressure of water-vapor, and the relative humidity may be rapidly and accurately obtained from the readings of the ventilated wet and dry bulb hygrometer.—M. B. R.

The Eupatheostat. A. F. Dufton. Journal Scientific Instruments, August 1929, pages 249-251.

An instrument for regulating the heating of a room is described.—M. B. R.

A New Aspiration Pyrometer (Ein neues Durchflusspyrometer) Siemens, Zeitschrift, July 1929, pages 453-454.

The new pyrometer destined for temperature measurements of flowing gases up to 1100°C. is intended to obviate inaccurate readings due to radiation and heat losses through walls and pipes. The gases are directed in such a manner that they pass a special ceramic body with the thermo-couple consisting of Ni-NiCr wires. Smallest gas quantity; 10 liters per second must pass the pyrometer.—E. F.

A New Surface Pyrometer (Ein neues Oberflaechenpyrometer) Siemens Zeitschrift, July 1929, page 454.

A improved portable thermo-couple permits measurements of any kinds of surfaces. Range 200°C. Thermo-couple wires: copper-constantan.—E. F.

Instruments for Determination of Atmospheric Humidity With Particular Consideration of the Cata-Thermometer (Instrumente zur Bestimmung der Luftfeuchtigkeit mit besonderer Behnadlung des Katathermometers) Dr. Loeber. Glas & Apparat, October 20, 1929, pages 207-209; November 3, 1929, pages 217-219.

Chemical methods, Baumhauer Hygrometer, dew-point method and instruments according to Daniell, Lambrecht, Doebereiner, Regnault, Crova and Dufour, condensation-hygrometer according to Nippolt, hair hygrometers of Saussure, Gay-Lussac and combination method of thermometer and hair-hygrometer of Lambrecht designated as "Polymeter," psychrometer for scientific purposes, aspiration-psychrometer according to Assmann, and its modification by Schubert, thermo-hygrometer with evaluation tables of Ebert, Draka-Hygrometer, Tycoshygrometer of the Taylor Instrument Co., are discussed and the Datathermometer and measurements with this instrument are fully considered.—E. F.

(Current Literature Review continued on Page 42)

The Measurement of Air Flow

By

E. Ower, B.Sc. (Lond.), Hons. I., A.C.G.I.

Bramwell Medallist; Member of the Institute of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory.

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II. General Principles of the Pressure Tube Anemometer.
III. Design of Pitot and Static Tubes.
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VI. The Plate Orifice, Venturi Tube, and Shaped Nozzle.
VII. The Vane Anemometer.
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IX. Manometers.
X. Methods of Flow Measurement Based upon the Rates of Cooling of Hot Bodies.

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CHEMICAL ANALYSIS

Phosphorous Determination, Iron and Steel. R. P. Hudson. Blast Furnace & Steel Plant, October 1929, pages 1507-1510.

Outlines practical methods which have been found both convenient and accurate.—M. S.

Contribution to the Analysis of Fuels. (Beitaege zur Analyse der Kraftstoffe). Dr. O. Simmina. Petroleum, July 31, 1929, pages 1061-1067.

A new method for the determination of the evaporation line is given working 30 times as quick as the conventional method. New ways are shown to determine the bromide number instead of the H_2SO_4 reaction which does not in all cases characterize the fuels. An improved method for determination of the aromatic constituents of benzene is suggested.—E. F.

Electrolytic Board for the Determination of Lead. O. W. Holmes and D. P. Morgan. Industrial & Engineering Chemistry, October 15, 1929, pages 210-212.

The apparatus is a modification of the Guess-Haultain cabinet and is designed to speed up the electrolytic determination of lead in low-grade mill tailings. Twenty-four samples can be run at one time. It is adaptable also for copper.—M. E. H.

Determination of Inert Gas Content of Gas Mixtures by Means of Calcium as an Absorbent. Martin Leatherman and Edward P. Bartlett, Oct. 15, 1929, pages 223-225.

An apparatus is described which permits the analysis of various gas mixtures for the noble gases by a method involving absorption of all the common gases, and the measurement of the change of pressure at constant volume. Results are reproducible to within 0.002 or 0.003 per cent.—M. E. H.

Studies in the Drying Oils. XI-Monomolecular Films of Blown and Heat-Bodied Oils and Their Constituent Fatty Acids and Esters on Water Surfaces. J. S. Long, W. W. Kittelberger, L. K. Scott & W. S. Egge. Industrial & Engineering Chemistry, October 1929, pages 950-955.

Presented before the Division of Paint and Varnish Chemistry at the Columbus Meeting of the American Chemical Society, April 1929. A modified Langmuir surface tension balance was used to study the orientation of blown and heat-bodies oils and their constituent fatty acids and esters.—M. E. H.

Determination of the Sulfur Content of Gases from Boiler Furnaces. Edmund Taylor & H. F. Johnstone. Industrial & Engineering Chemistry, Analytical Edition, October 15, 1929, pages 197-199.

Presented at the Columbus Meeting of the American Chemistry Society, April 1929. Apparatus and methods are described for sampling the gases after they have passed the boiler tubes and from the furnace. These are designed to reduce the possibility of catalytic action between the point of sampling and analyses.—M. E. H.

Recent Indicators (Neuere Indikatoren). Dr. R. Fresemus. Zeits. fuer angewandte Chemie, Sept. 7, 1929, pages 892-895.

The author reviews a number of chemical indicators and reagents, describes the methods of application and adds literature and bibliographical notes.—H. A.

Experiment Applications of Automatic pH Recorders to Sugar-Refinery Alkalinity Control. A. L. Holven. Industrial & Engineering Chemistry, October 1929, pages 965-970.

Presented before the Division of Sugar Chemistry at the Columbus Meeting of the American Chemistry Society, April 1929. The possibility of replacing colorimetric H-ion control of sugar refinery products by a centralized automatic control has been investigated. The author points out objections to the use of the bare-wire tungsten electrode in combination with the calomel half cell.—M. E. H.

Analysis Methods for Bitumen (Untersuchungsmethoden fuer Bitumen). H. Boesenberg. Petroleum, August 14, 1929, pages 1128-1134; Septemb er18, 1929, pages 1275-1279.

The author reviews the principal determinations of bitumen, i. e., in regard to specific gravity, solubility, softening point, depth of penetration, ductility, constancy of weight and illustrates the apparatus, mostly American, according to the standards of the A. S. T. M.—E. F.

The Use of Potentiometric Methods in Steel Plant Laboratories, Especially for the Determination of Manganese, Chromium and Vanadium Simultaneously (Die Anwendung der potentiometrischen Massanalyse in Eisenhuettenlaboratorium, insbesondere zur Bestimmung von Mangan, Chrom und Vanadin nebeneinander.) P. Dickens & G. Thanheiser. Archiv fuer Eisenhuettenwesen, October 1929, pages 277-291.

The nature of potentiometric titration and examples for the three most used methods are given. The advantages of potentiometric titration are compared with ordinary analytical analyses. The literature is reviewed.

The Segregation of Analyzed Samples. G. Frederick Smith, L. V. Hardy and E. L. Gard. Industrial & Engineering Chemistry, Analytical Edition, October 15, 1929, pages 228-230.

Presented before the Division of Chemical Education of the Amer. Chem. Soc. at the Columbus Meeting, April 1929. This article presents an apparatus for segregating mixtures. The apparatus consists of a jarring device and a carriage for two small ball-mill jars, both operated by one motor. A study of the effect of particle size and density on segregation, is the main purpose of the article.—M. E. H.

A Study of the Silver Chloride Electrode. Walter R. Carmody. Journal American Chemical Society, October 1929, pages 2901-2904.

A study of the factors that affect the potential of the AgCl electrode has been made. Directions are given for its preparation and care while being used. Results show that the electrolytically prepared Ag-AgCl electrode is quite as reproducible and constant as the hydrogen electrode.—M. E. H.

Advanced Mine Rescue Training. Part II Instructions in Methods of Sampling and in the Use of the Bureau of Mines Portable Orsat Apparatus for Analyzing Mine Gases. W. G. Yant & L. B. Berger. Miners' Circular 34, U. S. Bureau of Mines, 89 pages.

This part describes Bureau of Mines methods of sampling mine gases and the use of the portable Orsat apparatus for analyzing mine gases and gives instruction in its manipulation.—M. B. R.

Determination of Fluorine and of Silica in Glasses and Enamels Containing Fluorine. J. I. Hoffman & G. E. F. Lundell. Journal of Research, October 1929, pages 581-595.

Methods for the determination of fluorine and of silica in the presence of each other remain practically the same as those developed by Berzelius over 100 years ago. These methods are very tedious and normally give low results for both fluorine and silica. In the new methods that are described, the procedure for separating silica and alumina from fluorine has been modified so that it is more accurate and takes less time, while the old method of determining fluorine as calcium fluoride has been replaced by the more rapid and equally accurate lead chlorofluoride method.

(Current Literature Review continued on Page 43)

Determination of Manganese in Steel and Iron by the Persulphate-Arsenite Method. H. A. Bright & C. P. Larrabee. Journal of Research, October 1929, pages 573-579.

The advantage of using phosphoric acid in the persulphate-arsenite method and the effect of certain dissolved salts on the titration of permanganic acid by sodium arsenite are discussed. A description is given of the persulphate-arsenite method as used at the Bureau of Standards. In the recommended procedure, which embodies no new principles, as much as 20 mg of manganese can be handled. It is therefore possible to use 1 g samples in practically all cases. The results obtained by this procedure are much better than those obtained on smaller samples by the ordinary persulphate method and are practically of the same order of accuracy as obtained by the standard and much more elaborate bismuthate method.

The Determination of Sulphate in Chromic acid and in Chromium Plating Baths. H. H. Willard & R. Schneidewind. Preprint American Electrochemical Society, September 19, 1929, 14 pages.

Besides the whole chemistry of accurate sulphate determination in chromic acid, the authors consider the Parr Sulphur Photometer. Instead of measuring the depth of liquid required to extinguish the light, it has been found more accurate to maintain a fixed depth of liquid and vary the strength of the light, measuring the voltage across its terminals or the resistance in series with it.—E. F.

Proposals on the Standard Method Regarding the Determination of Melting Points in Analytical Standard Methods on Fats (Vorschlaege fuer die Vorschrift zur Schmelzpunktsbestimmung in den fettanalytischen Einheitsmethoden) H. Finke & G. Greitemann. Petroleum, August 20, 1929, pages 263-267.

The behavior of various sorts of fat is discussed in regard to the determination of melting point and a standard method is suggested.—E. F.

The Hydrosulfo Meter (Das Hydrosulfometer) R. Feibelmann & W. Meves. Chemische Fabrik, September 25, 1929, page 749.

The pattern of the "Chlorometer" of the Chemische Fabrik Pyrgos Radebeul-Dresden was modified for the new hydrosulfometer designed for testing hydrosulfite preparations.—E. F.

A Simple Method of Applying an Automatic Zero Point Adjustment to Burettes (Ein einfache Art, Burretten mit automatischer Nullpunkteinstellung zu versehen) J. Fisch. Chemiker Zeitung, October 12, 1929, page 799.

The simple device is schematically given and its operation explained. E. F.

Electrode Potentials of Copper Anodes and Copper Cathodes. E. F. Kern & R. W. Rowen. Preprint American Electrochemical Society, September 19, 1929, 14 pages.

A comparison of the results obtained by the use of the Haring polarisation and resistivity cell, by means of a saturated calomel half-cell, and a mercurous sulfate-cell, showed that the most satisfactory results were secured with the saturated calomel half-cell in connection with a potentiometer.—E. F.

Simple Methods of Potentiometric Titration of Acids and Bases. L. Kahlenberg & A. C. Krueger. Preprint American Electrochemical Society, September 19, 1929, 11 pages.

The traditional calomel electrode may be dispensed with. Using tungsten as one of the electrodes, a large number of other metals served very well as the other electrode. Equilibrium is reached most rapidly with the couples W-Cu, W-Ni, W-Si and W-Co which exhibit an actual change in polarity at the neutral point.—E. F.

Analysis of Carbon in Iron and Iron Alloys. N. A. Ziegler. Fuels & Furnaces, October 1929, pages 1621-1622.

Abstract of paper presented at meeting of the American Electrochemical Society, September 19-21, 1929. Method described is of advantage only for alloys containing less than 0.1% carbon. Consists in heating sample in a vacuum (0.003-0.001 mm. Hg.) to 900° -1100° C. and then oxidizing with chemically pure oxygen. The resultant gases are slowly evacuated first through a tube containing CuO to covert CO to CO_2 and then through a trap immersed in liquid air to freeze the CO_2 until pressure is about 0.001 mm. Upon warming the trap, the CO_2 is allowed to evaporate into a small known volume, and the amount of carbon is calculated from the pressure shown by a manometer. The vacuum furnace consists of a silica tube, the central part of which is wound with a nichrome heating element, enclosed in an asbestos box filled with sil-o-cel. The cooler part of the furnace has the nichrome heating element covered with alundum cement and asbestos tape.—M. S.

A Convenient Method for the Determination of the Sulfate Content of Chromium Plating Baths. L. E. Stott & A. W. Petchaft. Preprint American Electrochemical Society, September 19, 1929.

The Parr Sulphur Photometer can be used if strontium chloride be substituted and if the funnel of the instrument be made of glass throughout, so that no rubber comes in contact with the solutions of chromic acid. The accuracy of the new method is at least comparable to any heretofore used and is much more convenient and rapid, requiring neither a chemical balance nor complicated gravimentric procedure.—E. F.

The Application of Electron Tubes in Electrochemical Measurements (Het gebruik van trioden bij electrochemische metingen) A. H. W. Aten, L. Boerlage & D. Cannegieter. Chemisch Weekblad August 24, 1929, pages 426-430.

Electron tubes can advantageously be employed in measurements with alternating current in combination with the Wheatstone bridge for instance for potential measurements of cells of large internal resistance. A great number of circuits are discussed.—E. F.

Electrometric Titration (Die elektrometrische Titration) F. Emslander. Wochenschrift fuer Brauerei, October 5, 1929, pages 407-409.

Review of apparatus for determination of pH. Includes references.—E. F.

Analytical Balance For Elevated Temperatures. T. Somyia. Journal Society Chemical Industry, Japan, March 1929, page 75.

A new balance is described which rests at the zero point and has an accuracy of 1/10 milligram in spite of the elevated temperature of $T_{max} = 1300°$ C. This instrument largely consists of a suspension wire through the bottom of the balance case from one of the scale pans into an electric furnace. The useful application is illustrated by a heat run with calcium carbonate. The losses in weight due to decomposition exactly correspond to those derived from theoretical considerations. —E. F.

The Measurement of pH in Nickel Plating Solutions. W. Blum & N. Bekkedahl. Preprint American Electrochemical Society, September 19, 1929.

Since very slight differences in the acidity of Ni plating solutions may affect the character of the deposited metal, several methods for controlling the baths have been developed. The authors present their own investigations including the hydrogen and quinhydrone electrode measurements and the colorimetric methods as Buffer Indicator Tubes, Stirlen Wedge, Hellige Comparator, Drop Ratio Method.—E. F.

Application of Flue Gas Testers to Blast Furnace Stoves. (Anwendung des Rauchgaspruefers bei Hochofen-Winderhitzern) Ing. Hoelscher. Siemens Zeitschrift, July 1929, pages 446-448.

Investigations in blast furnace plant are carried out the results of which are reported and graphically presented. The advantageous use of the gas testing instrument is demonstrated resulting in an improvement of efficiency of 2.8% or the saving of 1,700,000 kcal per day.—E. F.